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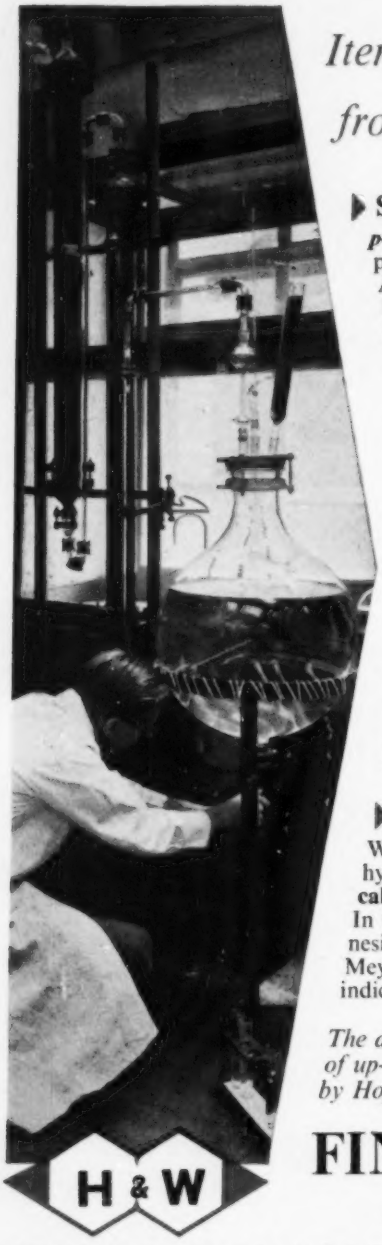

Items of interest

from our laboratory notebooks

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***p*-Nitrophenylphosphoric acid, disodium salt** (*di*-sodium *p*-nitrophenyl phosphate) is used as a substrate in the **milk phosphatase** test of Aschaffenburg and Mullen now gaining in popularity and recognition because of its simplicity and speed. (See *J. Dairy Res.*, **16,** 58 (1949), and *Dairy Ind.*, **18,** 316 (1953)).

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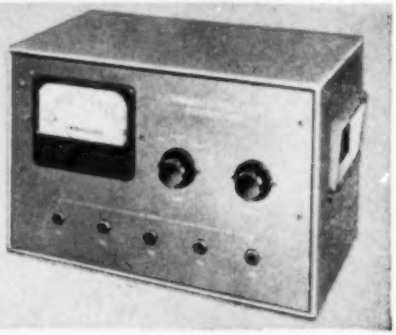

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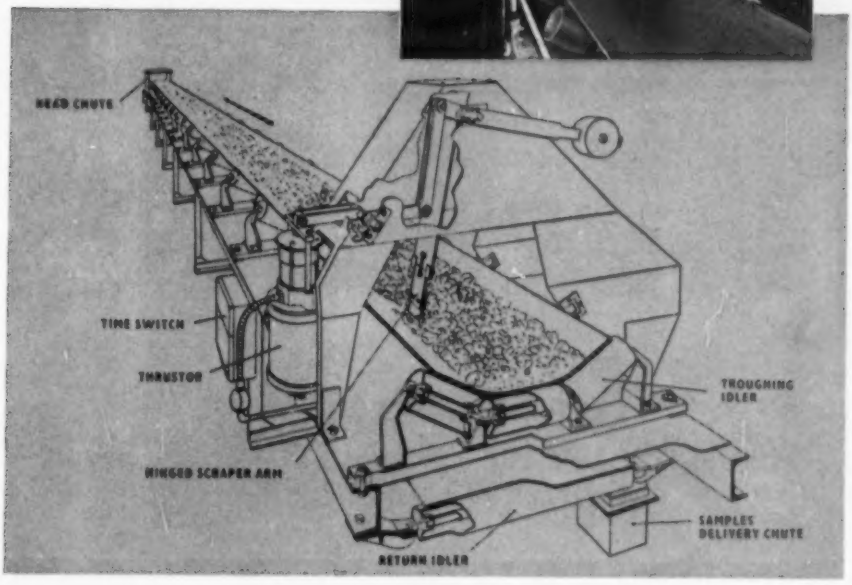

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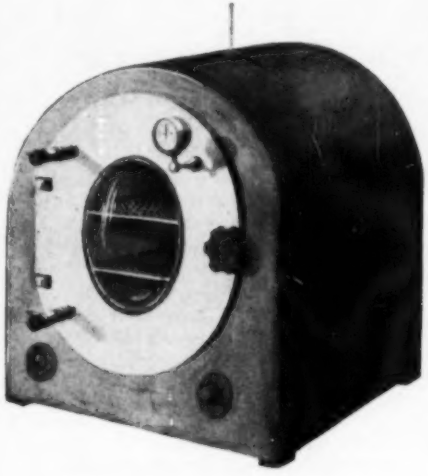

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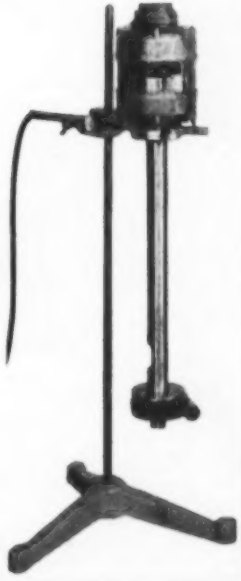

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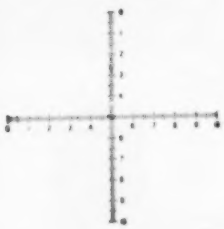

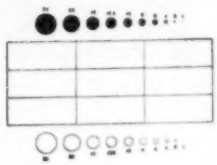

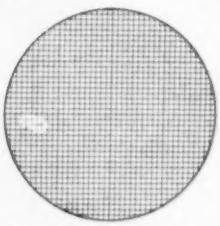

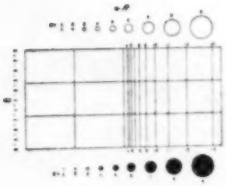

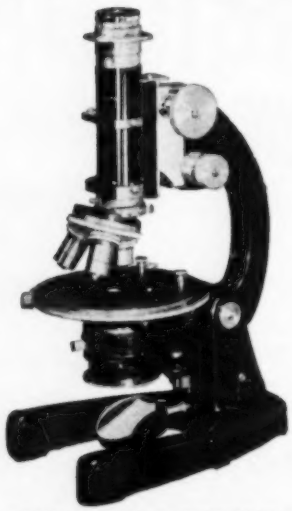

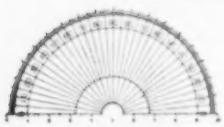

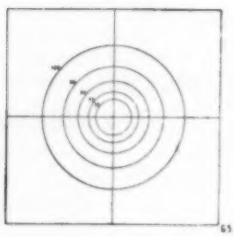

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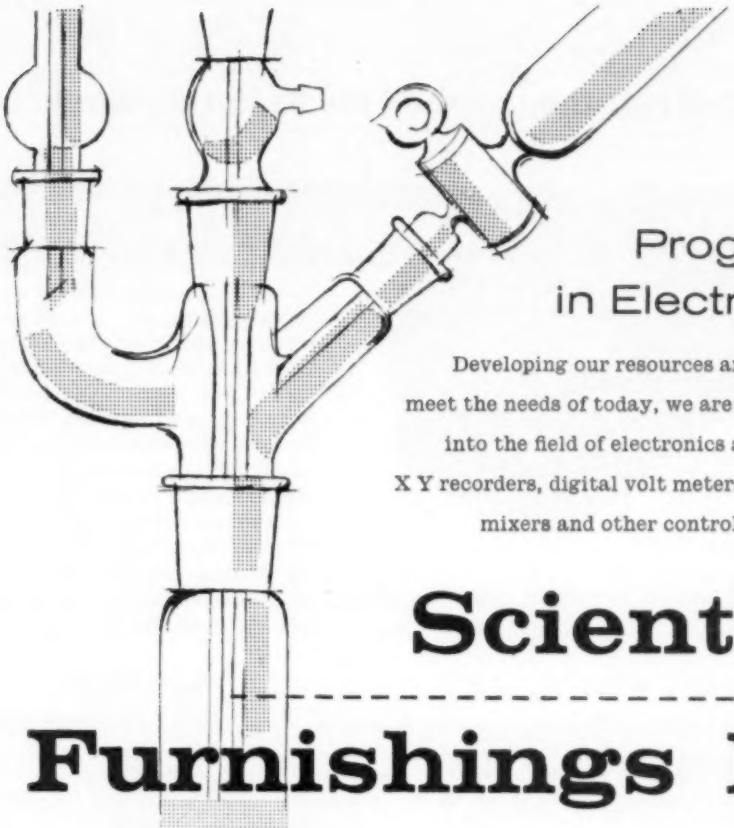

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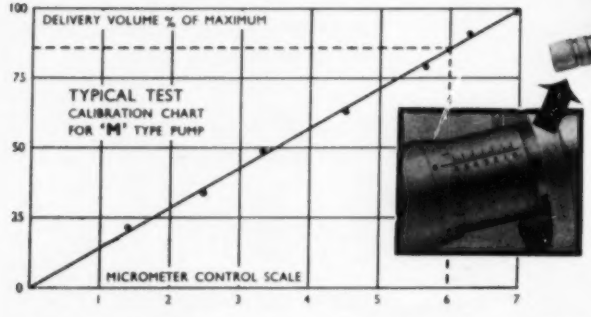

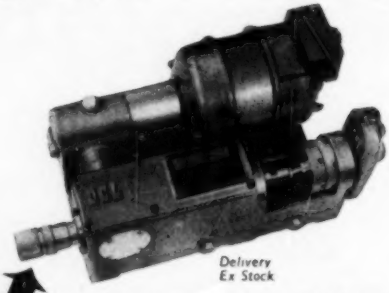

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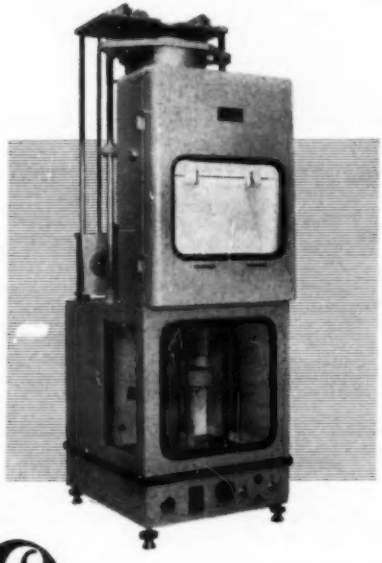

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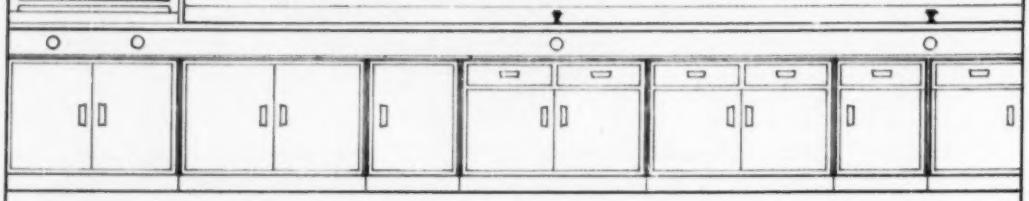

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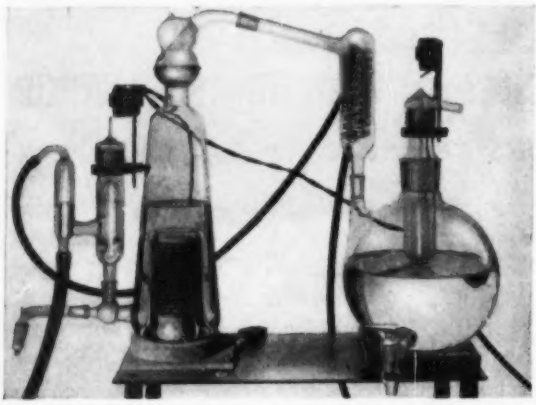

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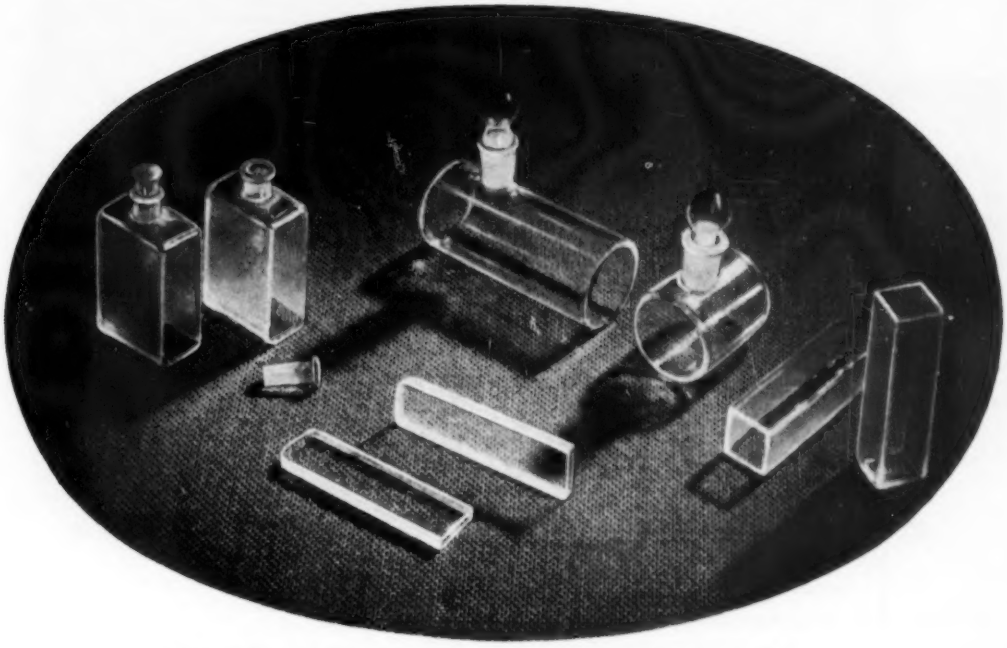

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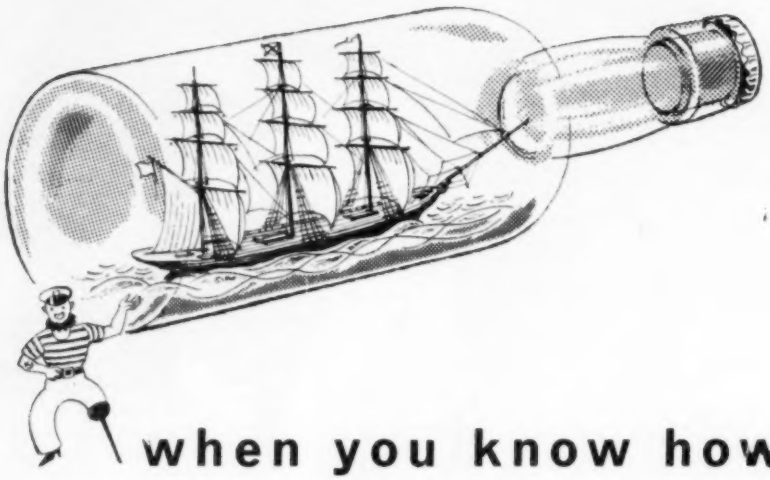

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EDITORIAL

Towards increased Productivity

SCIENTIFIC invention, particularly in the field of automation, has resulted in increases in productivity that would not have been believed by the pioneer workers in industries accustomed only to the methods then used.

The combine harvester enables one man to harvest grain 20 times as fast as previously. With a tractor one man can plough as fast as 50 men with 100 oxen. One man with a threshing machine can reach the output of over 130 men using the old fashioned flails. In the factory one girl with a modern spinning machine can equal the output of 300 girls equipped with only the old spindles.

These are only a few examples of how technology has transformed the efficiency of human beings in producing not only manufactured goods but food, the one commodity that we cannot do without. Coupled with the new machines are the new production methods—work studies, time studies, management studies—all designed to increase the ratio of production to time and physical effort.

The latest method has been built up on the basis of the *break system*, which now dominates most productive, and indeed many purely scientific organizations. This system, now elaborated to a high degree, had its origin in quite a humble beginning. As sociology became a highly developed science it was realized that human beings could not go on working continuously for as long as two or three hours, and so breaks were introduced to relieve the strain. The system was in use in a rudimentary form before the war when a solitary mid-morning break was made for coffee, and an afternoon break for tea. Since the war growth has been rapid. Breaks for 'pep' talks by the management were an early feature, and group discussion meetings between workers and management were a logical sequel.

Not to be outdone by the employers, the workers rapidly absorbed the idea, and breaks soon became a highly organized aspect of production. Breaks for meetings called by the union, breaks for meetings not

called by the union, breaks for meetings of the football club selection committee (invariably the best attended), breaks for meetings of the drama club, breaks for meetings of the benevolent association, the allotment holders, the gramophone society, the table tennis club, the film society, the canteen committee (mostly people who did not use the canteen) and a number of other important organizations are now scattered throughout the day like stars in the firmament at night.

The best organized firms have a special break committee to allocate the time for breaks and to establish priorities where these are necessary.

We venture to make a contribution to the modern break system in industry. Like all world-shattering ideas this one is really quite simple. It is that in all organizations there should be a *work break*. Some time every morning, or afternoon if this is more convenient, a period should be set aside during which work would be done without interruption of any kind. Naturally such a revolutionary scheme would cause some dislocation of existing methods at first, but we suggest that the idea should be given a fair trial. In time it might be seen that results would justify the new scheme. The human organism has amazing powers of adaptability and reserves of strength, and we feel that after a short settling down period, production might once more resume its smooth course. It might even increase, in which case it might be adopted as a permanent feature of industry. Increased production could then more than justify some of the most recently devised breaks, such as the second tea break for those who actually go on working until 5 o'clock, or return from lunch too late for the normal tea break.

Recent British Standards

Laboratory Equipment (B.S. 1792:1960 and B.S. 572:1960) Work carried out by the International Organization for Standardization (ISO) has been taken into account in the preparation of revised British Standards relating to one-mark volumetric flasks and interchangeable conical ground glass joints.

Standard for one-mark volumetric flasks (*B.S.* 1792:1960. *Price 4s.*)—This standard is a revised edition of that first published in 1952 under the title 'One-mark graduated flasks'. As before, ten sizes of flask from 5 ml. to 2,000 ml. are included and only the essential dimensions are specified as mandatory, the rest being given for manufacturers' guidance.

The most important changes from the previous edition (which take into account the ISO work on the subject) are:

The tolerances on capacity have been adjusted slightly so that those for Class B flasks are now double those for Class A flasks.

The recommended base diameter has been increased for most sizes and it is now specified (for flasks larger than 10 ml. capacity) that the empty flask (without stopper) shall not topple when placed on a non-slip surface inclined at an angle of 15° to the horizontal, instead of 10° as formerly.

The necks of the two smallest and four largest sizes of flask are not permitted to be quite so narrow as formerly and separate maximum limits for internal diameter of neck are specified for Class A and Class B flasks in the case of the 5 and 10 ml. sizes.

The inscription 'In' replaces 'C' as an indication that the flasks are graduated 'to contain', it having been found in the course of the international discussions that 'In' and 'Ex' (to replace 'D' for 'to deliver') are more generally acceptable than any of the abbreviations previously used in various countries.

It is required that the type of glass of which the flasks are made shall be identifiable, at least as far as Class A flasks are concerned.

Standard for Interchangeable conical ground glass joints (*B.S.* 572: 1960. *Price 4s.*)—A revised edition of the 1950 Standard of the same title, this standard (which takes into account the work of the ISO on the subject) differs from its predecessor as follows:

The B16, C21, C26, and C32 joints have been omitted, as experience has shown that they are relatively little used.

The dimensions of certain of the joints have been altered slightly, but not so as to prevent cones or sockets complying with this standard from being used interchangeably with those complying with the previous edition.

The tolerance permitted on the specified taper has been reduced, in keeping with the results achieved by modern methods of manufacture.

The steel gauges for the joints are now dimensioned in millimetres instead of inches.

The inscription 'B.S. 572' on the joint is no longer specified as mandatory, as it is felt that the joint number (e.g. 'B24') is sufficiently well recognized as an indication of the standard with which the joint purports to comply.

Copies of these standards may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

Royal Society Medals

The following awards of medals have been made by the President and the Council of the Royal Society:

The Copley Medal to Sir Harold Jeffreys, F.R.S., formerly Plumian professor of astronomy in the University of Cambridge, for his distinguished work in many branches of geophysics, and also in the theory of probability and astronomy.

The Rumford Medal to Dr. A. G. Gaydon, F.R.S., Warren Research Fellow, for his distinguished work in the field of molecular spectroscopy and particularly its application to the study of flame phenomena.

The Davy Medal to Prof. J. M. Robertson, F.R.S., Gardiner Professor of chemistry and administrative head of the Chemical Laboratories in the University of Glasgow, for his distinguished pioneering work on analysis of crystal structure, especially of organic compounds.

The Darwin Medal to Mr. E. J. H. Corner, F.R.S., reader in plant taxonomy in the University of Cambridge, for his distinguished and strikingly original botanical work in tropical forests.

The Hughes Medal to Dr. J. L. Pawsey, F.R.S., assistant chief of the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization, Australia, for his distinguished contributions to radio astronomy both in the study of solar and of cosmic radio emission.

RECENT DEVELOPMENTS IN GAS-LIQUID CHROMATOGRAPHY

by A. T. James

National Institute for Medical Research, Mill Hill, London, N.W.7

Dr. James delivers his lecture.

OF ALL the chromatographic techniques, gas-liquid chromatography has achieved the most spectacular success. This is due not only to the earlier impact of liquid-liquid chromatography but also to the way in which the gas chromatogram combines the interests of organic chemists, biochemists, physical chemists, professional and amateur electronic engineers and mathematical physicists. Instrument manufacturers have taken up the technique quite rapidly possibly because unlike the older liquid-liquid chromatogram, instrumentation is easier, although often the size of the box produced might lead one to suppose the opposite.

The advantages of the gas-liquid chromatogram reside mainly in the use of a permanent gas as the moving phase. High diffusivities of the solute in the gas enable the use of long thin columns having relatively small amounts of stationary phase so that substances can be separated rapidly. The ease with which vapours can be detected in gases even at very low concentrations makes automatic recording of solute bands relatively simple.

The most significant advances in the technique during the past few years have been in the development of much more sensitive detectors, the development of high efficiency packed columns and coated tubes and also in methods for qualitative analysis of specific types of chemical compound.

The older vapour detectors such as the catharometer, the gas-density meter, and the hydrogen flame detector give useful results at concentrations down to approximately 1 in 10^5. This is adequate for packed columns with loads of the order of a mgm. Recently developed detectors utilizing changes in the ionization properties of gases now enable loads of a fraction of a microgram to be used.

Harley *et al.* (1958) and McWilliam and Dewar (1958) developed a detector based on the hydrogen flame instrument invented by Scott (1957). These workers measured the ionization current in the flame instead of the heat evolved, when a vapour is burnt. In Fig. 1 is

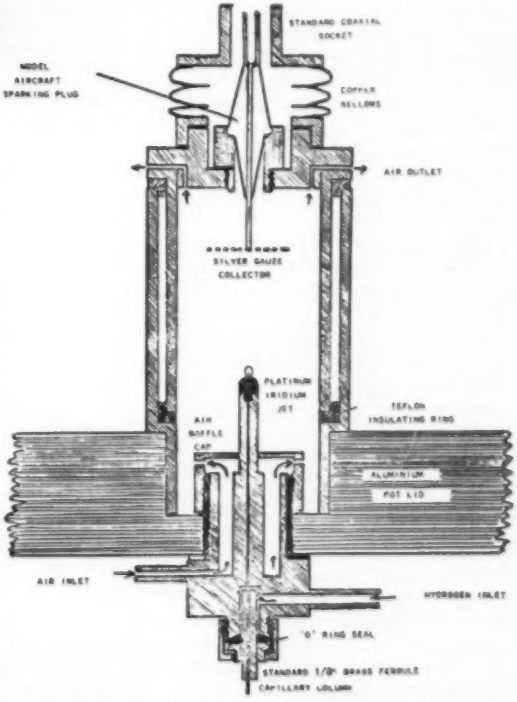


Fig. 1. Hydrogen flame ionization detector (after Desty, Goldrup and Whyman (1959)).

This lecture was delivered at the recent Laboratory Apparatus and Materials Exhibition under the chairmanship of Prof. H. D. Kay.

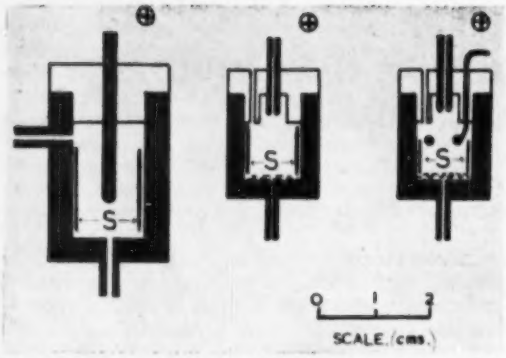


Fig. 2. The family of argon detectors (after Lovelock, (1960.))

shown a version of the instrument used by Desty and his collaborators (1959).

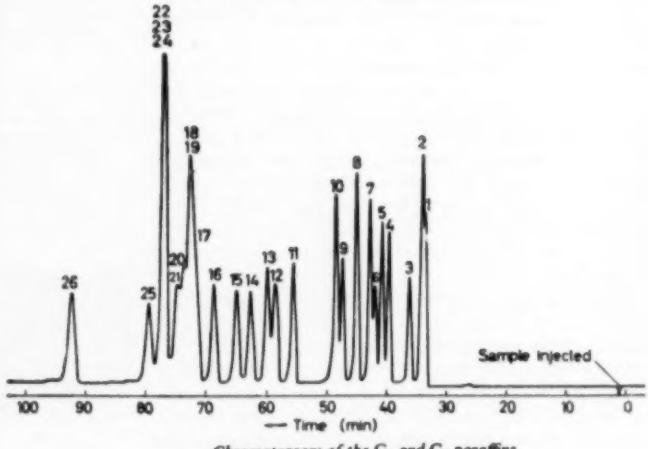
The gas used as mobile phase of the chromatogram is usually nitrogen, at the end of the column hydrogen at constant flow rate is injected and the mixture is burnt in a draught-proof enclosure. A potential is applied between the metal jet and a silver gauze electrode. The ionization current picked up is amplified usually by a vibrating reed electrometer, whose output operates a servo recorder. The instrument has a high sensitivity (lowest detectable concentration of less than 1 in 10^{12}) and a wide linear range. For the highest sensitivities it is important that the jet has a large thermal mass to prevent its becoming sufficiently hot for thermionic emission to occur. The response varies with the structure of the vapour being burnt so that calibration is necessary for accurate results.

The family of argon detectors developed by Lovelock (1958) Lovelock *et al.* (1959), Lipsky *et al.* (1959) and Lovelock and Lipsky (1960) is notable not only for high sensitivity but also for great flexibility. The three main types of detectors are shown in Fig. 2 (Lovelock 1960). These detectors depend for their operation on the production of excited but un-ionized argon atoms by electron bombardment utilizing a radioactive source and a high potential. When organic vapour molecules enter the cell collision occurs between a proportion of the molecules and the metastable argon atoms, a transfer of energy takes place with the production of ionized vapour molecules. The primary electron current in the cell is roughly 10^{11} electrons per second and if each electron can generate 10^4 metastable atoms then, as Lovelock (1960) has demonstrated, the steady state concentration of metastable argon atoms will be of the order of 10^{10} per cc. This means that a molecule of organic vapour has a 1·6:1 probability of being ionized in one second, and explains the very high ionization efficiency and hence the high sensitivity of the latest argon detectors. Lovelock (1960) has presented experimental results for the minimum detectable concentration achieved with each of the cells (Table 1).

The energy of the metastable argon atoms is 11·7 ev, higher than most organic and inorganic substances. The cells are therefore insensitive only to a few materials such as H_2, M_2, O_2, CO_2, CO, $(CN)_2$, H_2O and fluorocarbons. A low response is also given by methane, ethane, acetonitrile and propionitrile.

There has been much discussion of the relative merits of the argon detectors and the hydrogen flame ionization detectors. The recent symposium on gas-chromatography at Edinburgh has done much to clear the air. The flame ionization detector has the advantage of a larger linear range and the argon detectors have the advantage of higher sensitivity and flexibility. There is room for both devices for we have yet to discover the perfect detector.

1. 2,2-Dimethylpentane
2. 2,4-Dimethylpentane
3. 2,2,3-Trimethylbutane
4. 3,3-Dimethylpentane
5. 2-Methylhexane
6. 2,3-Dimethylpentane
7. 3-Methylhexane
8. 3-Ethylpentane
9. 2,2,4-Trimethylpentane
10. *n*-Heptane
11. 2,2-Dimethylhexane
12. 2,5-Dimethylhexane
13. 2,4-Dimethylhexane
14. 2,2,3-Trimethylpentane
15. 3,3,-Dimethylhexane
16. 2,3,4-Trimethylpentane
17. 2,3-Dimethylhexane
18. 2-Methylheptane
19. 2-Methyl-3-ethylpentane
20. 2,3,3-Trimethylpentane
21. 4-Methylheptane
22. 3-Methylheptane
23. 3-Ethylhexane
24. 3,4-Dimethylhexane
25. 3-Methyl-3-ethylpentane
26. *n*-Octane



Chromatogram of the C_7 and C_8 paraffins

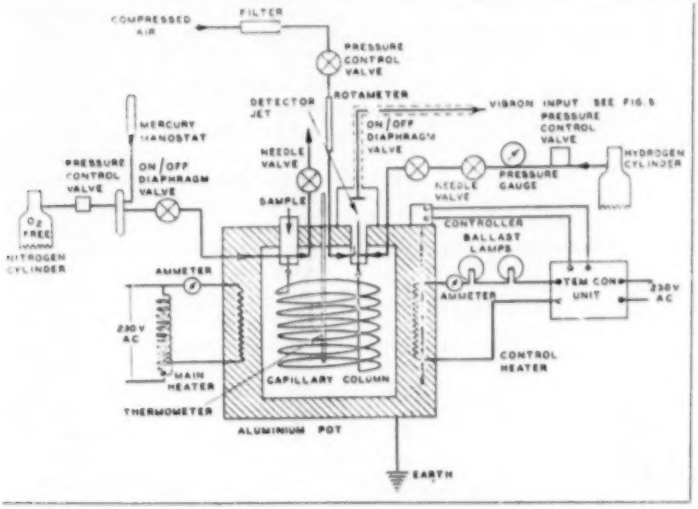
Operating temperature: 78·5°C
Column packing: 2)°/. w/w Apiezon oil on C_{22} 110–120 mesh brick
Fluent gas: Argon
Column length: 50 ft.
Column diameter: 2·2 mm
Inlet pressure: 200 lb./in² (Constriction at end of column $P_i/P_o < 1·2$)
Detector: Argon β-ray ionization cell
Sample weight: Approximately 20 μg
Column efficiency: About 30,000 theoretical plates

Fig. 3. The use of long packed columns having high efficiencies (after R. P. W. Scott (1958)).

TABLE 1

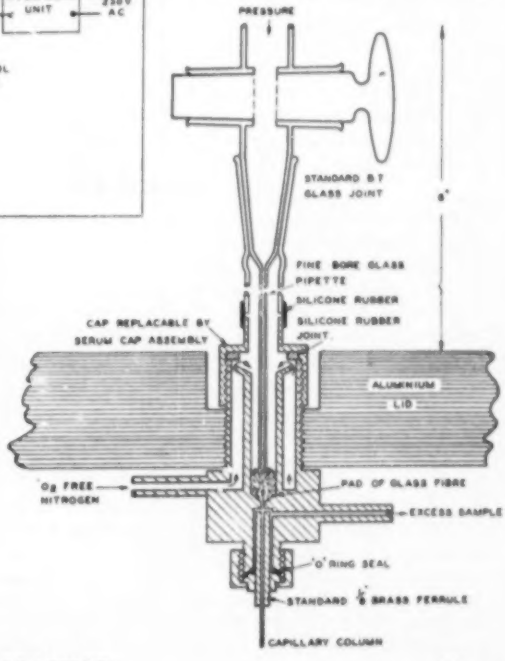
Some characteristics of argon detectors (after Lovelock, 1960)

Characteristic	Cell type		
	Simple diode	Small diode	Triode
Minimum detectable concentration in g./ml. at 20 ml. per min.	4×10^{-11}	$1{\cdot}2 \times 10^{-12}$	6×10^{-14}
Maximum current consistent with linear response (amps)	7×10^{-8}	3×10^{-7}	4×10^{-7}
Deviation of linearity over a 1000-fold range of vapour concentration	3·1	1·2	1·2



◀ **Fig. 4. General arrangement of a capillary column apparatus (after Desty, Goldrup and Whyman (1959)).**

Fig. 5. Apparatus for applying the sample to a capillary column (after ▼ Desty, Goldrup and Whyman (1959)).



Two factors control separations on a gas-liquid chromatogram: (1) the difference in partial vapour pressure between the substances to be resolved and (2) the number of theoretical plates or equilibrium stages in the column. In the hands of Scott (1958) very high column efficiencies have been obtained from long packed columns (Fig. 3). Golay (1958) in the United States however predicted on theoretical grounds that high efficiencies should be obtainable from lengths of narrow bore tubes whose walls carried a thin film of stationary phase. He proceeded to verify this experimentally. The most elegant development of this new type of chromatogram was carried out in this country by D. H. Desty and his collaborators (1959) and by R. P. W. Scott and his group (1960).

In Fig. 4 is shown a schematic diagram of the apparatus used by Desty. The more theoretical plates a column can possess the smaller the volume of gas must

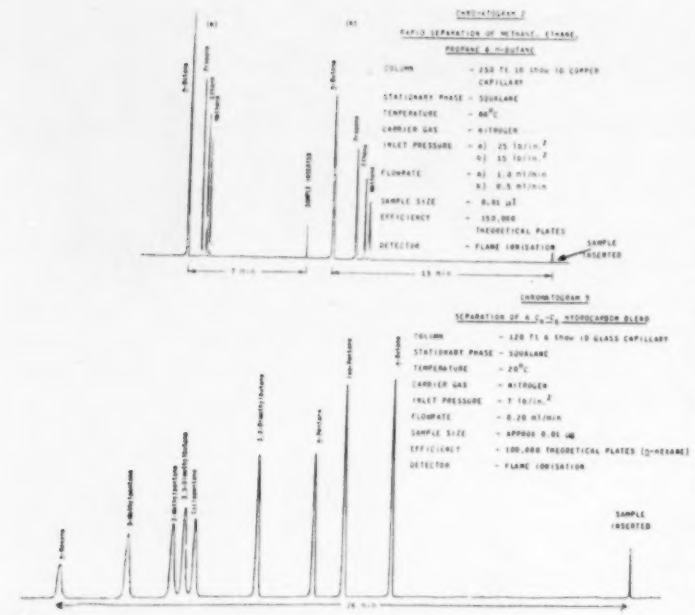


Fig. 6

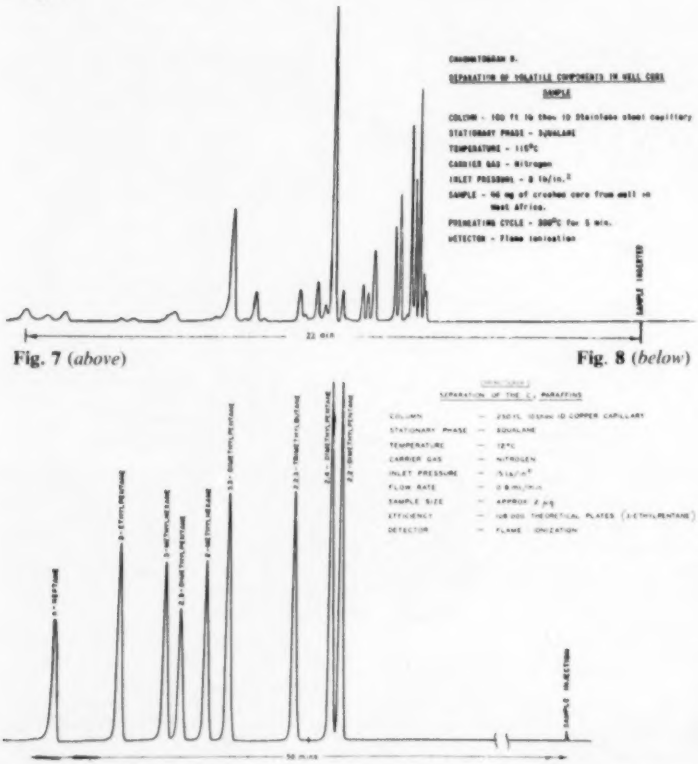


Fig. 7 (*above*)

Fig. 8 (*below*)

be used to inject the sample. Loading is carried out by blowing the sample over the end of the capillary tube at such a velocity compared with that passing through the tube that only a small fraction of the sample enters the column (Fig. 5). Separations typical of those obtainable on these high efficiency columns are shown in Figs. 6, 7 and 8.

It should be noted that very high column efficiencies are necessary only for very difficult separations particularly in the hydrocarbon field. When separation factors can be increased by the use of a selective stationary phase, fewer plates are necessary (Fig. 9).

Desty has used capillary columns constructed of copper, stainless steel, gold (no doubt one of the advantages of working for a petroleum company) and also of glass. He has found that glass columns are superior in their smoothness of wall and hence ability to accept a thin film of liquid phase.

The very small amounts of liquid phase in these capillary columns means that retention volumes (i.e. the volume of gas required to elute a substance) are also small. Scott (1960) has utilized this property to carry out separations in a few seconds on nylon capillary columns. The conventional potentiometric recorders are too slow in response for these columns so Scott has used an oscilloscope as a recorder. The circuitary associated with this apparatus is shown in Fig. 10.

Fig. 11 shows separation of a low boiling petroleum ether on a relatively short nylon column at room temperature. Such separations are ideal for automatic plant control because of the ability to adjust process streams rapidly in accord with the analysis.

Fig. 6. Separation of low molecular weight hydrocarbons on capillary columns (after Desty, Goldrup and Whyman (1959)).

Fig. 7. Separation of volatile materials from a crushed sample of oil drilling core (after Desty, Goldrup and Whyman (1959)).

Fig. 8. Separation of the C7 paraffins on a capillary column (after Desty, Goldrup and Whyman (1959)).

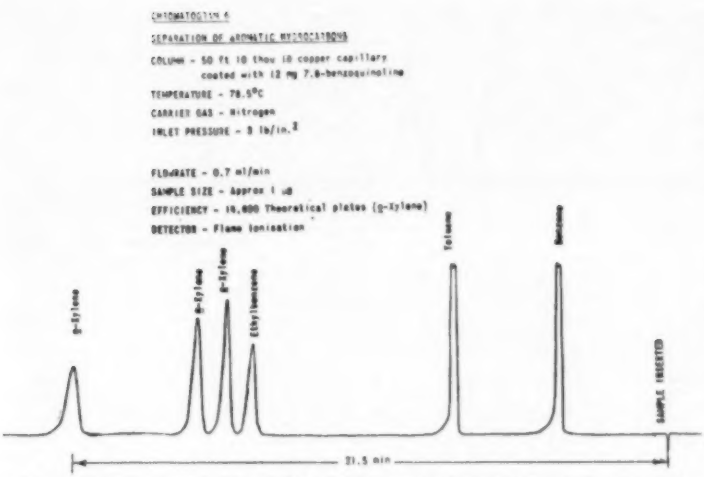


Fig. 9. The use of a selective stationary phase and a high efficiency column for the separation of p⁻ and m⁻ xylene (after Desty, Goldrup and Whyman (1959)).

COMPONENTS FOR OSCILLOSCOPE

Valves

V_1, V_2 OB2.
V_3 ME1400.
V_4, V_9 12AT7.
V_5 EF37A.
V_6, V_7 EL84.
V_8 6AL5.
V_{10} 2 × EL84.
V_{11} 2 × EL84.
V_{12} 12AX7.
V_{13} 14/03TB.

Resistors

All resistors ±10% tolerance, ½ watt, unless otherwise stated.
R_1 3·3 K. ohm, 3 watt.
R_2 50 K. ohm wire-wound potentiometer (set zero).
R_3 3·9 M. ohm.
R_4 2·5 × 10^8 ohm.
R_5, R_{18}, R_{22}, R_{45}, R_{49} 1·0 M. ohm.
R_6, R_{15}, R_{52} 470 K. ohm.
R_7 150 K. ohm.
R_8 220 K. ohm.
R_9, R_{12} 100 ohm.
R_{10}, R_{13} 4·7 K. ohm, 1 watt.
R_{11}, R_{14} 15 K. ohm, 2 watt.
R_{16} 50 K. ohm potentiometer ('Y' amplitude).
R_{17}, R_{23}, R_{36}, R_{37}, R_{38} 100 ohm, 2 watt.
R_{19}, R_{21} 15 K. ohm.
R_{20} 50 ohm, 1 watt.
R_{24}, R_{30} 680 K. ohm.
R_{25}, R_{42} 100 K. ohm preset potentiometers.
R_{26}, R_{43} 47 K. ohm.
R_{27} 100 K. ohm potentiometer ('Y' centre).
R_{28}, R_{44} 22 K. ohm.
R_{29}, R_{47} 2·2 K. ohm.
R_{31} 250 K. ohm potentiometer ('X' amplitude).
R_{32} 120 K. ohm.
R_{33} 100 K. ohm motor-driven potentiometer (Colvern Ltd.).
R_{34}, R_{48} 10 K. ohm.
R_{35}, R_{39} 1 K. ohm.
R_{40} 100 K. ohm potentiometer ('X' centre).
R_{41} 1·2 M. ohm.
R_{46} 270 K. ohm.
R_{50} 1 M. ohm potentiometer (focus).
R_{51} 250 K. ohm potentiometer (brilliance).
R_{53} 2·2 M. ohm.
R_{54} 100 K. ohm.
R_{55} 2 M. ohm potentiometer (pulse brightening).

Condensers

C_1 30 picofarad, 500 v. D.C. ceramic.
C_2, C_4, C_6, C_8, C_{10}, C_{12}, C_{14}, C_{16} 0·1 mfd., 500 v. D.C. paper.
C_3 0·01 mfd., 500 v. D.C. paper.
C_5, C_9 32 mfd., 450 v. D.C. electrolytic.
C_7 0·002 mfd., 150 v. D.C. paper.
C_{11} 0·2 mfd., 500 v. D.C. paper.
C_{13}, C_{15}, C_{17} 0·5 mfd., 500 v. D.C. paper.

Coils

L_1L_2 Push-Pull 'Y' scan coil.
L_3L_4 Push-Pull 'X' scan coil.

Ferranti Ltd.

Whilst high efficiency columns were being developed other methods of separation and identification were being investigated. Minor differences in chemical structure of components of mixtures can be caused to bring about large changes in partial vapour pressures of the component by correct choice of solvent in the column. This can be illustrated with the long chain fatty acids. These substances occur naturally as complex mixtures of unsaturated and saturated acids of a variety of chain lengths.

When a column having as stationary phase a non-polar saturated paraffin hydrocarbon is used, molecular weight is the main factor controlling separation in this solvent, unsaturated acids emerge before saturated acids of the same chain length. In general, the more unsaturation, the earlier a substance comes out of the column (see James (1960) for a general survey).

A solvent possessing a number of ester groups, e.g. a polymer of ethylene glycol and adipic acid, shows a specific interaction with unsaturated acids. The saturated and unsaturated acids change position in comparison with a non-polar stationary phase. Plotting the $\log_{10}$ times of emergence of a variety of fatty acids in the non-polar solvent against the values obtained in the polar solvent gives the result shown in Fig. 12. The values for acids of similar structure fall on straight lines, each line being characteristic of a given degree of unsaturation. Determination of the time of emergence of an unknown acid in each solvent thus allows prediction of the number of carbon atoms and double bonds in the molecule (James, 1959).

An alternative approach to this use of selective stationary phases is to use a vapour detector having a selective response. The most promising of such detectors is the electron capture argon detector developed by Lovelock (*see* Lovelock and Lipsky, 1960). When a gas is ionized electrons can be picked up by neutral molecules to give large negative ions.

$M^o + e^- \rightleftharpoons M^- +$ energy. The ease with which an electron can be picked up depends on the electron affinity of the molecule, i.e. upon its substituent groups. The electron affinities of groups such as C=O, -COOR, C-OH, C-N, etc, are different and can be used as a method of classification. The measurement of such affinities can be carried out on flowing gas streams by using a modified argon diode detector at a potential lying between 0 and 100 volts. By choice of a suitable potential, different classes of compound can be caused to give negative peaks, the magnitude of which is characteristic of a particular group. In this way the

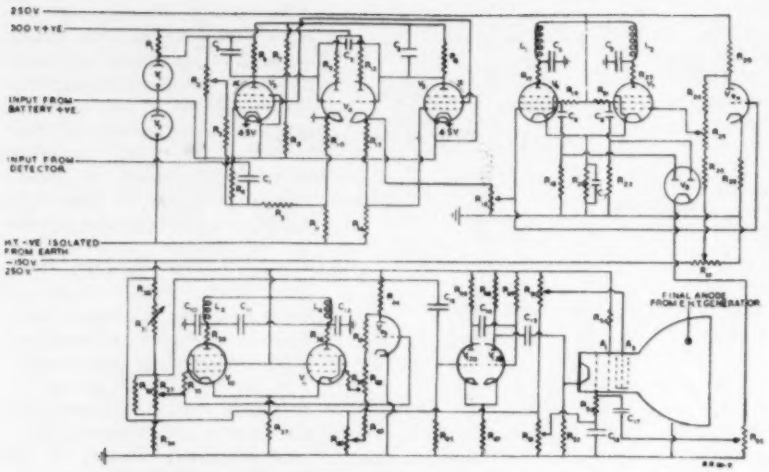


Fig. 10. Circuit of oscilloscope used to present high speed chromatograms (after Scott and Cumming (1960)).

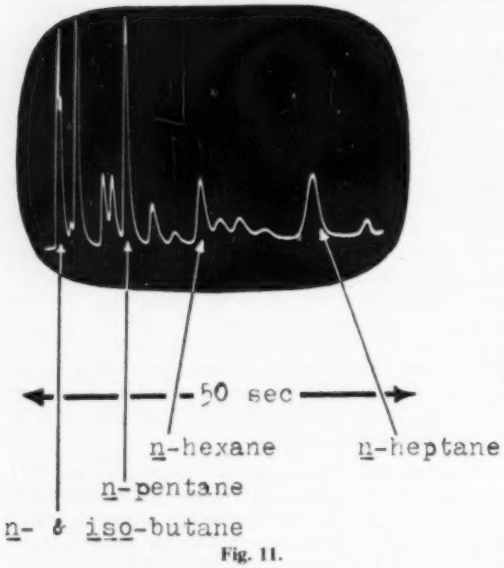


Fig. 11.

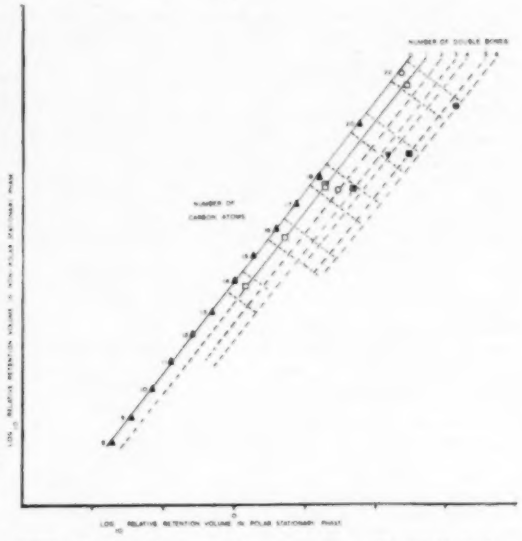


Fig. 12 (*above*)

Fig. 13 (*below*)

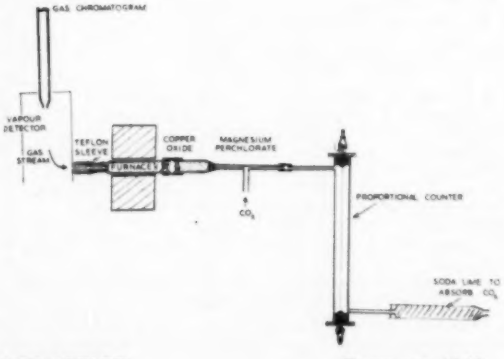


Fig. 11 Separation of petrol ether in 50 seconds on a 70 ft. nylon capillary column (after Scott and Cumming (1960)). Nylon column 0·020 in. diameter. Liquid phase 8 mg. of Apiezon oil A. Micro-argon detector. Charge ≈ 2-4 μg. Efficiency for n-hexane 5000-6000 theoretical plates. Total elution time 80 sec. Linear gas velocity 1000 cm./sec. Dead time 29 sec. Width of butane peak 0·5 sec.

Fig. 12. The relationship between Log $_{10}$ relative retention volume in a non-polar and a polar stationary phase for a variety of saturated and unsaturated acids. By the use of this grid an unknown acid can be identified.

Fig. 13. Schematic diagram of a flow proportional counter for the determination of radioactivity in the gas stream from a gas chromatogram.

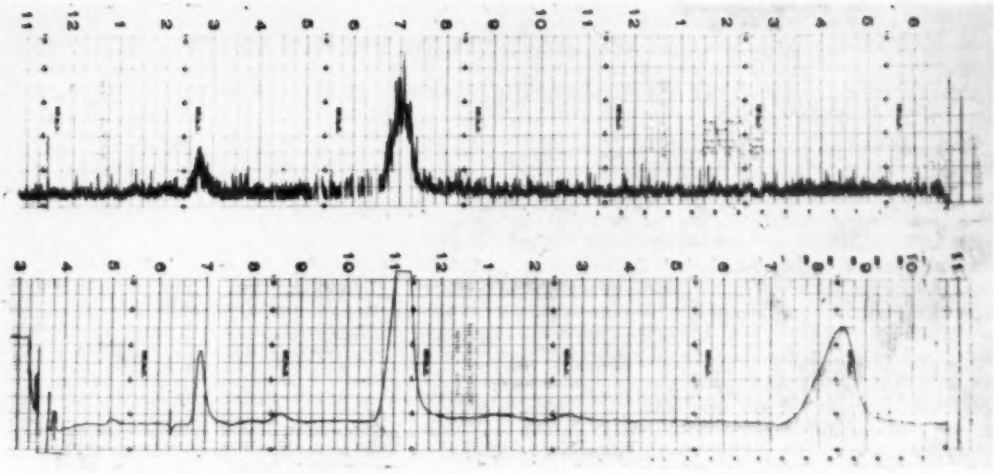


Fig. 14. Record of zones from (above) gas density vapour detector and (below) flow proportional counter.

detector can be made blind to some substances and highly sensitive to others so that identification can be made easy.

The use of radioactive isotopes in both chemistry and biochemistry for following reaction mechanisms is now general. Various methods have recently been employed to detect the radioactive atoms in substances separated by the gas-liquid chromatogram. Karmen and Tritch (1960) have isolated fractions with traps containing crystals of anthracene wetted with silicone oil, suitable for direct insertion into a scintillation counter. Popjak *et al.* (1959) have devised an apparatus in which the gas stream from the chromatogram passes into a glass cell containing a solution of a scintillator in an organic solvent. The cell is held between two refrigerated photomultipliers and by the use of a coincidence circuit high sensitivities can be obtained.

I have preferred a somewhat simpler arrangement (James and Piper, 1960). Argon is used as the moving phase in the chromatogram and a short heated combustion chamber of quartz is fitted to the outlet of the vapour detector. The silica tube contains copper oxide and any organic vapour, whether a zone, or stationary phase from the column, is burnt to CO_2 and water. The water is removed by a tube packed with magnesium perchlorate and the gas stream passes to a mixer where 5 per cent of CO_2 is injected (Fig. 13). The stream then enters a simple proportional counter constructed from $\frac{1}{2}$ in. I.D. copper water pipe, having polythene insulating plugs fitted with a 2/1000 in. diameter tungsten wire along its axis. The wire is held in position by narrow bore rubber tube. The counter is connected to a conventional head amplifier and ratemeter, the output of which is fed to a recorder. In this way the vapour detector records the amount of material and the counter the amount of radioactivity (Fig. 14), enabling specific activities to be readily determined.

In this lecture I have attempted to cover a few of the more interesting developments of gas chromatography. Many important extensions of the technique have been left out by pressure of time alone.

ACKNOWLEDGMENTS.—*Thanks are due to Mr. D. H. Desty, Mr. R. P. W. Scott and Dr. J. E. Lovelock and the Institute of Petroleum and Butterworths Scientific Publications Limited for permission to reproduce diagrams already published and those as yet unpublished.*

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Society for Applied Bacteriology

The next meeting of the Society for Applied Bacteriology will be held on Wednesday, January 11, 1961 at the Barnes Hall, Royal Society of Medicine, 1 Wimpole Street, London. In the morning a paper reading session will be held. In the afternoon commencing at 2.15, there will be a joint meeting with the Microbiology Group of the Society of Chemical Industry when papers will be presented on Quantitative Microbiology.

ION EXCHANGE CHROMATOGRAPHY

by J. P. Redfern, Ph.D., B.Sc., A.R.I.C.

THE use of ion-exchange resins in industrial, medical and biochemical, inorganic and organic fields is now well established. At present papers, patents, and reviews dealing with various aspects of the subject are appearing at the rate of over 1,500 a year. The present article is confined to one aspect of ion exchange, namely, that of ion-exchange chromatography which finds application in all of the branches of chemistry mentioned above.

Ion-exchange chromatography may be applied to the separation—for the purposes of purification, preparation, or for identification (either qualitatively or quantitatively)—of complex mixtures of closely related substances such as the rare earths, the chloro-complexes of many metals, or the amino acids.

Three types of ion-exchange chromatography have been recognized. These are:

(i) Frontal analysis
(ii) Displacement development
(iii) Elution development.

In addition two other types of ion-exchange chromatography have been described. These are partition chromatography and salting-out chromatography. In these two applications use is made of properties of ion-exchange resins other than the ability to exchange ions.

(i) *Frontal analysis.*—In frontal analysis a solution containing a mixture of ions to be separated is passed through a column of resin containing exchangeable ions which are held less firmly than any of the ions to be sorbed from the solution. Fig. 1a shows the changes in concentration of the ions appearing in the effluent from the column. A solution containing X ions and Y ions (in the ratio of 1:2 g. equiv./l.) is passed through a column of resin initially in the Z form. As the solution is passed into the column X and Y ions are sorbed on the top of the resin column and, after the displacement of the water initially present in the column, Z ions will appear in the effluent and their concentration will rise to a value equivalent to that of the total concentration of X and Y. When all the Z ions have been displaced from the column, the X ions which are less firmly sorbed than the Y ions will appear in the effluent alone. On continued passage of the solution through the column Y ions will then appear in the effluent as well, and the concentration of Y will rise and that of X will fall so that finally the concentration of X and Y ions in the effluent will be the same as in the original solution. In this way it is possible to separate and identify from a mixture of ions of the same sign that ion which is least strongly sorbed on a resin column. Such a method is of limited use and few papers have appeared in which it has been applied to a specific separation.

(ii) *Displacement development.*—In this procedure a quantity of solution containing a mixture of ions to be separated is passed through a column of resin containing ions which are sorbed less strongly than any of the ions in the solution. Only partial loading, usually some 5-10 per cent of the length of the resin column, is employed. The column is then developed using a second solution containing ions which are more strongly sorbed than any of the ions in the first solution. Fig. 1b shows the changes in concentration of the ions appearing in the effluent from a column initially in the Z form with a band at the top containing X and Y ions. On passage of the developing solution containing W ions which are more strongly sorbed than either X or Y ions, Z ions appear in the effluent at first and then X and Y ions will appear successively each at a concentration equivalent to that of the developing solution. Finally W ions will appear in the effluent and the concentration will quickly rise to that of the developing solution. The disadvantages of this method are that the bands of X and Y which appear on the resin and in the effluent overlap so that some of the fractions will contain mixtures of the two ions. However, if small

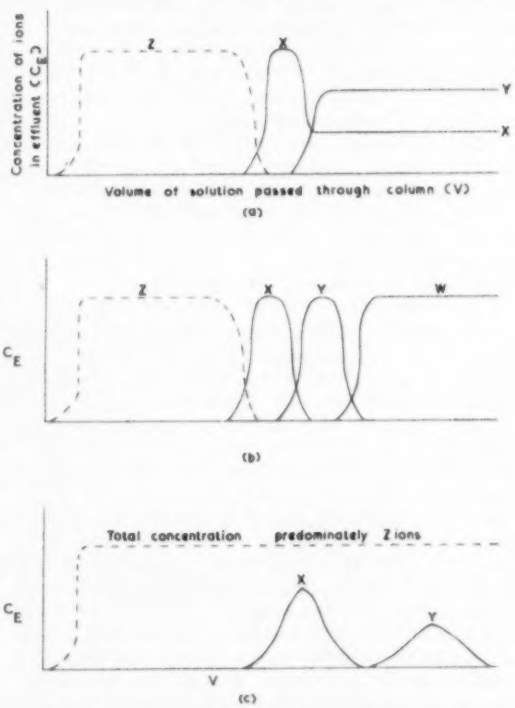

Fig. 1. Ion-exchange chromatography. (*a*) Frontal analysis. (*b*) Displacement development. (*c*) Elution development.

fractions are taken some will contain X ions only and some Y only. Unless the resin column has been prepared very carefully the development of the bands may well be uneven resulting in even greater overlap. The advantages of this method are that one obtains an effluent which contains X and Y in relatively high concentrations. Because of the overlap of successive bands, displacement-development chromatography is not very suitable where quantitative separations are desired, its use being confined to preparative work and to obtaining some quantity of each of the constituents of a mixture in a pure state in solution for purposes of identification. The method has been applied to the separation of the amino acids by Partridge (1954), to a study of the species present in boiled chromic perchlorate solutions by Laswick and Plane (1959), and in the isolation of a hypotensive substance γ-aminobutyric acid in the course of phytochemical and pharmacological studies on Viscum album by Samuelsson (1959).

(iii) *Elution development*.—This procedure is the most versatile and most often used in ion-exchange chromatography, and is one by which a number of very elegant separations have been achieved.

There are two types of elution chromatography, (*a*) straight elution, and (*b*) complexing elution.

(*a*) In straight elution a quantity of solution containing the mixture of ions to be separated is passed through the column of resin, and, as in the case of displacement development, the column is only partially loaded. The column is developed using a second solution which contains ions which are less strongly sorbed than any of the ions of the mixture, often the same as those ions originally on the resin. As the solution is passed through the column some of the exchanging ions will pass through the band on the resin containing the mixture of ions, others will exchange with the ions in the band. Thus the ions to be separated will move down the column gradually on prolonged passage of the eluting solution. The initial band separates under the influence of the eluting ions into bands containing the separate constituents. The separation will depend on the relative affinities of the various ions for the resin. These bands will have diffuse boundaries. As the bands move down the column so the amount of separation between bands increases but at the same time they become more diffuse. Fig. 1c indicates the changes in concentration of the ions in the effluent when a solution containing Z ions is used to separate the mixture of X and Y ions sorbed as a band at the top of the resin column initially in the Z form. It will be seen that the concentration of the separated ions in the effluent fractions is low, and that the fractions contain a large excess of the eluting agent (eluant).

(*b*) Complexing elution is, however, the method employed in most separations. If the eluant contains a complexing agent then two factors affect the distribution of ions between the resin and the solution:

Factor 1. The relative affinities of the ions for the resin.

Factor 2. The concentration of free X and Y ions in the solution immediately in contact with the resin.

Any complexing agent present in the solution will lower the concentration of free X and Y ions in the solution. If a mixture of metal ions is sorbed at the top of a column and a solution containing H^+ ions is passed down the column there will tend to be an elution of the metal ions.

$$\overline{M^{m+}} + mH^+ \rightleftharpoons M^{m+} + m\overline{H^+} \quad \ldots 1$$

(where barred formulae refer to ions in the resin phase). When M is polyvalent there is little tendency for reaction 1 to go from right to left. If the concentration of H^+ ions is increased the tendency of M to come off the resin will be increased. But in the separation of several polyvalent metals any differences in the affinities will be lessened under these conditions and a poor separation will result. If, however, the eluant contains an anion A^{a-} which forms complexes with the metal ions, the following equilibrium will exist along with 1 above:

$$M^{m+} + xA^{a-} \rightleftharpoons [MA_x]^{(xa-m)-} \quad \ldots 2$$

The concentration of free M ions is thus effectively reduced and as a result the equilibrium in reaction 1 above will be displaced to the right. Consequently the metal which most readily forms complexes with the eluant will tend to be eluted first. In most cases it is the metal which tends by factor 1 to be eluted first which most readily forms complexes so that the initial tendency towards separation is increased by employing a complexing agent.

Gradient Elution

In applying either straight or complexing elution to the actual problem of separating a given mixture often it is found necessary to change the strength of the eluant from time to time in order that the volume of liquid passed through the column is not excessive, and that the concentration of the later components of the mixture to be eluted from the column may be kept at a reasonable level. This may be done by a complete change of the eluant by replacing a solution of low concentration by a higher. This procedure can be carried out where the affinities of the ions to be separated are very different. An excellent example is afforded by the cationic complexes of chromium (III) with thiocyanate. King and Dismukes (1952) aged solutions of chromium (III) nitrate with potassium thiocyanate by heating at 100°C. for three hours. The cationic complexes which are found in such solutions were eluted from a strongly acidic cation exchanger using perchloric acid as the eluant and a clear separation achieved.

$[Cr(H_2O)_4(SCN)_2]^+$	eluted with 0·15 M $HClO_4$
$[Cr(H_2O)_5(SCN)]^{2+}$	eluted with 1·0 M $HClO_4$
$[Cr(H_2O)_6]^{3+}$	eluted with 5·0 M $HClO_4$

This procedure is referred to as a step-wise elution. With a complex mixture the separation may be facilitated using a continuously changing concentration of eluant—generally referred to as gradient elution.

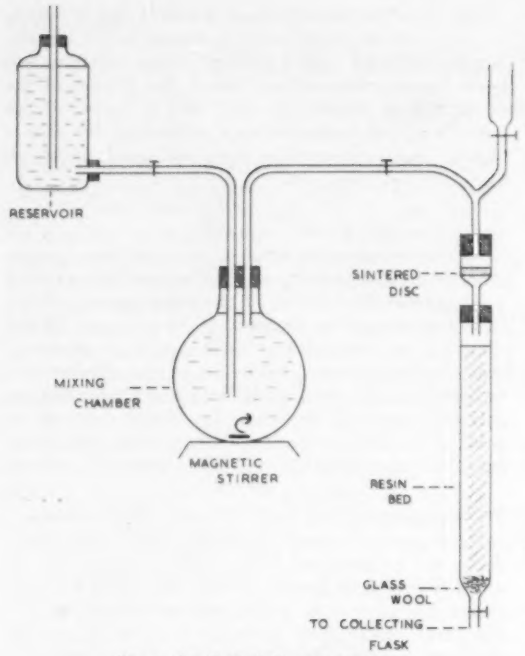

Fig. 2. Gradient elution apparatus.

The design of a suitable apparatus for use in conjunction with an ion-exchange column 30 × 1·5 cm. is shown in Fig. 2. It will deliver an eluant of continuously increasing concentration (or, alternatively, if required, continuously decreasing concentration). A 1 or 2 litre aspirator acts as a reservoir containing the eluant of the final desired composition. This solution is led into an air-tight 500 ml. or 1 litre bolthead flask, acting as a mixing chamber, which is stirred continuously by means of a magnetic stirrer. Initially the mixing chamber contains eluant of the desired initial composition. Solution from the mixing chamber is led to the top of the ion-exchange column. Stopcocks are fitted as indicated to enable any part of the apparatus to be isolated from the rest. It is possible, by introducing the side-arm and separating funnel, to introduce the solution containing the mixture of ions to be separated into the resin column without dismantling the apparatus. In order to facilitate the handling of the resin in the column a sintered glass disc may be fitted at the top of the column; this has the advantage of trapping any solid particles which could contaminate the resin bed and also to prevent the resin particles themselves from flowing into the rest of the apparatus when backwashing is carried out to settle the resin column. By starting with suitable concentrations for the solutions in the mixing chamber and the reservoir it is possible to achieve a clear separation of the ions sorbed on the resin column. It is possible to derive an expression (Ernst and Redfern 1959) for giving the exact concentration of the eluant entering the column after any given time. The concentration of the solution entering the column at time t is given by:

$$v_0 \ln \frac{c_0 - c_1}{c - c_1} = v \qquad \ldots 3$$

where c = concentration of eluant leaving mixing chamber at time t.
c_1 = concentration of solution in the reservoir.
c_0 = initial concentration of solution in the mixing chamber.
v = volume delivered to the top of resin column after time t.
v_0 = volume of liquid in the mixing chamber (constant throughout the experiment).

The equation may be rearranged to give c directly:

$$c = \frac{c_1 (e^{v/v_0} - 1) + c_0}{e^{v/v_0}} \qquad \ldots 4$$

If the mixing chamber contains water initially then equation 4 reduces to

$$c = \frac{c_1 (e^{v/v_0} - 1)}{e^{v/v_0}} \qquad \ldots 5$$

The validity of equation 4 has been tested by Bisset (1959). He employed 12 N hydrochloric acid in the

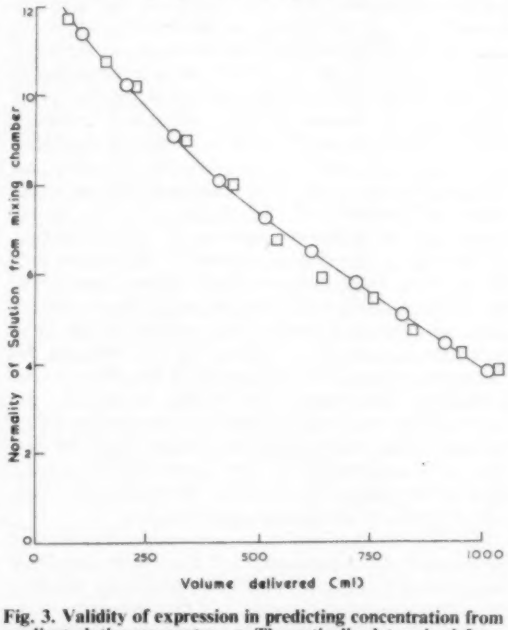

Fig. 3. Validity of expression in predicting concentration from gradient elution apparatus. ○ Theoretically determined from equation 5. □ Experimentally determined.

mixing chamber and water in the reservoir. The predicted curve and the experimentally determined curve are given in Fig. 3. Recently Crouch and Swainbank (1960) have described an apparatus for an automatic linear pH change in the eluant used on cation exchange micro columns.

There have been a number of treatments of the theory of gradient elution. Freiling (1955 and 1957) has deduced equations for predicting peak locations and peak shapes. Piez (1956) has obtained equations for relating pH change to effluent volume. The equations are applicable to pH changes produced by the addition of one buffer to another or by the addition of acid (or base) to a buffer under a variety of different experimental conditions. He showed that with the proper choice of conditions nearly any pH gradient can be obtained. In practice the method of gradient elution has been shown to possess a number of advantages over discontinuous or step-wise elution. These may best be discussed by reference to an actual example (Redfern and Salmon 1960). On aging a solution containing chromium (III) and phosphoric acid at 70°C. the resulting green solution contains a number of chromium phosphate complexes—principally cationic and closely related in properties. Initially a step-wise elution of the complexes was attempted on ZeoKarb 225 cation-exchange resin using nitric acid as the eluting agent. It was found that on changing from one concentration to a higher one, which was generally made after a complex had just been desorbed from the column (the judgment of this being made by eye as the complexes were all green in colour and showed up clearly against the background of the light-coloured resin) often there appeared at the base of the resin column a band of sorbed

TABLE I

Ion exchange chromatography—Gradient elution of chromium (III) complexes in solutions of constant P_2O_5 concentration after aging at 70°.

Solution		Complexes in order of elution	v_0 ml.	c_1		Cr found mmoles	PO_4 found mmoles	Cr : PO_4 mole ratio
Cr molal	PO_4 molal			NH_4NO_3 N	HNO_3 N			
0·039	2·113	A	550	1·00	—	0·054	0·109	1 : 2·02
0·196	2·113	A	575	0·66	—	0·196	0·406	1 : 2·07
		B		0·66	—	0·077	0·111	1 : 1·45
		C		0·66	—	0·065	0·088	1 : 1·36
0·392	2·113	A	580	0·66	—	0·182	0·364	1 : 2·00
		B		0·66	—	0·138	0·201	1 : 1·46
		C		0·66	—	0·112	0·156	1 : 1·38
		D		0·66	4	0·049	0·060	1 : 1·22
		G		—	8	0·101	0·051	1·99 : 1
0·588	2·113	A	580	0·66	—	0·073	0·179	1 : 2·47
		B		0·66	—	0·071	0·102	1 : 1·45
		C		0·66	—	0·038	0·050	1 : 1·33
		D		0·66	4	0·106	—	1 : 1·25+
		E		0·66	4	1·155	0·160	1 : 1·12
		F		0·66	4	0·150	0·152	1 : 1·01
0·784	2·113	A	580	0·66	—	0·032	0·064	1 : 1·99
		B		0·66	—	0·087	0·140	1 : 1·61
		C		0·66	—	0·026	0·035	1 : 1·33
		D		0·66	4		was not detected	
		E		0·66	4	0·258	0·295	1 : 1·14 +
		F		0·66	4	0·177	0·178	1 : 1·00

2% cross-linked ZeoKarb 225 (50-100 mesh) in the hydrogen form was contained in a column 1·2 × 33 cm. The results are given only on the main portion of the eluted complex.

½ g. samples of the resin were shaken with 10 g. of the fully aged solution for two hours, washed phosphate free on a sintered glass filter before loading on to the top of the prepared column. v_0 and c_1 have the significance as given in equation 3.

+ by inference—also indicated in some preliminary chromatographic work.

complex where one had not been observed before. This led to the assumption that another complex had been found when all that had been observed was that the previous complex had not been completely desorbed and the passage of the more concentrated eluant 'sharpened up' the tail of this band of complex. Employing gradient elution this effect was eliminated and, provided that the concentration values of the two initial solutions and the volume of the mixing chamber were correctly chosen, a clearer and more reliable separation was achieved. Typical results for some of the complexes found in some solutions are given in Table I.

It is often observed in the development of a band of a substance sorbed on an ion-exchange resin column that the band shape becomes skew and has a long 'tail'. The use of gradient elution considerably reduces this tendency, which often prevents a clear separation being achieved in practice even though such a separation is theoretically possible. If the concentration of acid eluant promoting movement of the front boundary of the band of, say, metal ions M^{m+} is c_x initially, as the eluant contains ions which are sorbed less strongly than the ions M^{m+} sorbed on the resin, the eluant will 'travel faster' down the column than the band of M^{m+}, and after time dt the concentration of the eluant will have increased to c_{x+dx} and the equilibrium

$$\overline{M^{m+}} + mH^+ \rightleftharpoons \overline{mH^+} + M^{m+} \quad \ldots 6$$

will be further displaced to the right and the metal ions will be more readily desorbed, i.e. it will not be held so firmly by the resin and will then travel faster down the resin column. Obviously the tail of any such band will be in contact with eluant of even higher concentration than the leading boundary, and hence will tend to be even more readily desorbed. Thus the use of gradient elution will result in the production of sharper peaks with reduced tailing effects. In the case of the chromium phosphate system outlined above a clearer separation of the bands was achieved and the results of the analysis, in order to assign possible mole ratios of chromium: phosphate to the complexes, were accordingly more trustworthy. Further the use of gradient elution speeds up the operation of separation, particularly where a large number of constituents are involved.

Since the introduction of this technique to ion-exchange chromatographic separations it has been applied with consistent success to numerous separations. One of the most elegant and outstanding has been the separation of some 50 ninhydrin-positive amino acids on Dowex 50-X4 by Moore and Stein (1954). These workers employed a jacketed column some 150 cm. in length and an eluant of constantly changing pH and ionic strength. The method permits the recovery of most amino acids within 3 per cent of theory in a single chromatogram using a pH range between 3·1-5·1 produced by using sodium acetate-citrate buffers of gradually increasing ionic strength. Stein and Moore, Tallen, Moore and Stein, Hirs, Stein, and Moore (1954) employed the technique to studies on the amino acids and related compounds in human blood plasma, tissue extracts, as well as the amino-acid composition of protein. The technique has also been applied to the separation of the rare earths, for example by Nervik (1955) and Bunney, Freiling, McIsaac, and Scadden (1957); to the separation of condensed phosphate anions by Grande and Beukenkamp (1956); and to the separation of some nucleotides by Pontis and Blumson (1958).

Ion-exchange chromatography is thus seen to be an extremely valuable method for separating mixtures of ions. The technique of gradient elution greatly enhances the versatility and ease of operation of such separations.

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The Nutrition Society

The following is the programme of a symposium on Calorie Balance in Man to be held at the Middlesex Hospital Medical School, London, W.1. on Saturday, December 17, 1960, under the chairmanship of Sir Charles Dodds, F.R.S.

Dr. J. V. G. A. Durnin (Institute of Physiology, The University, Glasgow, W.2).	'Basic physiological factors affecting calorie balance'
Dr. O. G. Edholm (M.R.C. Laboratories, London, N.W.3).	'The effect of environmental temperature on food intake'
Dr. Raymond Greene (106 Harley Street, London, W.1).	'The effects of the endocrine system on calorie balance in man'
Dr. T. M. Chalmers, (The Middlesex Hospital, London, W.1).	'Metabolism of adipose tissue'
Dr. G. C. Kennedy, (Department of Experimental Medicine, Cambridge).	'Central nervous regulation of calorie balance'
Dr. A. M. Thomson and Dr. F. Hytten (Midwifery Department University of Aberdeen).	'Calorie requirements in pregnancy and lactation'
Dr. E. M. Widdowson (Department of Experimental Medicine, Cambridge).	'Energy balance in early life'

Further particulars may be obtained from the Hon. Programmes Secretary of The Nutrition Society—Miss D. F. Hollingsworth, c/o Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

EMULSIONS IN VIVO*

by A. C. Frazer

Department of Medical Biochemistry and Pharmacology, University of Birmingham

THERE are four sites in the body where an oil-in-water emulsion can, under suitable metabolic circumstances, be readily demonstrated in the human or animal body. They are the lumen of the small intestine, the intestinal absorbing cells, the chyle, which is lymph leaving the intestine, and the blood. In this paper I propose to consider these emulsions; their composition and structure, their origin and formation, their significance, with special reference to lipid transport and metabolism, and the methods by which they can be studied.

Emulsified Fat in the Lumen of the Small Intestine

More than 100 years ago Claude Bernard[1] observed that fine emulsification of fats occurred in the lumen of the small intestine. He also noticed that in the rabbit, in which animal the pancreatic and bile ducts open separately, the fat had to pass both ducts before emulsification occurred. The existence of this finely dispersed emulsion is easily demonstrated by feeding an unemulsified oil and recovering it from the lumen of the small intestine; this can be done directly in animals, or by intubation in animals or man. The particle size averages less than 0·5 μ and many of the particles are extremely small.

It was thought at one time that bile salts were responsible for this fine emulsification, but it can easily be shown that they do not cause such fine dispersion under the conditions found in the small intestinal lumen. Again, emulsification due to soap formation is not a satisfactory explanation, because the reaction is often too acid for effective soap stabilization. Examination of all the possible factors under intestinal conditions, either singly, or in double or triple combination, clearly showed that only the triple combination of fatty acid, lower glyceride and bile salts was effective.[2] At about the same time we were also able to show that pancreatic lipase did not rapidly and completely hydrolyse triglyceride to fatty acids and glycerol, as had been previously thought, but removed the fatty acids one at a time, giving rise to di- and monoglycerides.[3] It was clear, therefore, that pancreatic lipolysis thus provided two of the three necessary components of the intestinal emulsifying system; the third being added in the bile. This gave striking support to Claude Bernard's simple observation, made 90 years previousiy.

It is, of course, possible to have considerable variation in the substances present in the oil phase or involved in the interfacial structure. However, it is not necessary to have more than the three substances, fatty acids, lower glycerides and bile salts, for fine dispersion to occur. Their importance is supported by observations in human subjects. The absence of pancreatic lipase results in interference with fat absorption, and faulty emulsification in the small intestinal lumen can be readily demonstrated.[4] Similarly, in occasional patients, bile salts are deficient with a similar effect on fat absorption.[5] The addition of the appropriate missing factor to samples withdrawn from the lumen results in the re-establishment of fine emulsification. A most interesting type of patient is one with a specific deficiency of pancreatic lipase; one such patient is described in the literature.[6] We are fortunate enough to have another patient with this rare enzyme defect under our care at the present time.

What is the significance of fine emulsification of fat in the small intestinal lumen? In the past it was generally thought that fine emulsification simply had a facilitating effect on hydrolysis; it does have such an effect, but only to quite a limited extent. We now know that hydrolysis of triglycerides in the intestinal lumen is not complete and that absorption of glycerides can occur as such.[7] It was, therefore, a matter of some interest to discover whether this fine dispersion of the glyceride fraction played any significant part in the absorptive mechanism.

First, it may be mentioned that the replacement of pancreatic lipase or bile salts goes a long way towards re-establishing normal fat absorption;[8] it is usually not completely successful. An important point in the study of hydrolysis was the behaviour of paraffins in the intestine; these studies also have some relevance to fine emulsification. Paraffin alone is poorly absorbed; emulsification does not occur because it is not hydrolysed and therefore the emulsifying system, dependent upon fatty acid and lower glyceride, is not formed. However, if the paraffin is finely emulsified and injected into the duodenum absorption occurs.[2] Alternatively, the paraffin can be fed as a mixture with an emulsifiable glyceride, such as olive oil. Under these circumstances both the olive oil and the paraffin are absorbed. This has been shown in short-term and long-term studies and has since been confirmed using 14C labelled hexadecane.[9]

Another series of studies that reveal a similar dependence upon fine dispersion are concerned with castor oil. This oil is a bland material, which, as everyone knows, causes catharsis, if given alone. This is due to hydrolysis of the bland oil in the small intestinal lumen by the action of lipase with the consequent release of ricinoleic acid, which is generally considered to be a strong irritant. Strangely, however, the administration

* A lecture delivered on February 4, 1960, to the Derby and District Technical College.

of ricinoleic acid does not cause catharsis. If the oil is examined in the intestinal lumen it will be found that the castor oil is poorly emulsified; it is consequently poorly absorbed and passes down to the lower parts of the bowel, where the liberation of ricinoleic acid brings about the cathartic effect. If the castor oil is mixed with olive oil and this mixture is fed, emulsification is normal and the castor oil is readily absorbed; no catharsis occurs.[10]

One final observation will be described which, I think, shows conclusively the importance of fine emulsification, in the fat absorption mechanism. This type of study is carried out in patients with no pancreatic lipase, but normal small intestinal function; a number of methods have been developed which enable us to sort out such a group. The intestine in these patients will readily absorb substances like glucose and only fails to absorb fat because the pancreatic lipase is missing. This is shown by the fact that no particulate fat appears in the systemic blood after fat feeding; normally a marked increase would be seen. Is this due to faulty emulsification in the intestinal lumen? This question can be readily answered by introducing finely dispersed fat into the small intestinal lumen; if this is done, a dramatic increase of particulate blood fat occurs.[11] This clearly shows that fine emulsification of fat is an important step in the mechanism of absorption of glycerides from the small intestine.

We have recently learnt a lot about the structure of the intestinal cell. Ten years ago, it was known that the intestinal columnar cells had a peculiar outer border; it seemed to be striated and was called the 'brush border'. Its precise structure was, however, the subject of much argument and discussion. The development of electron microscopy has completely dispelled all doubts about the structure of the 'brush border'; it consists of fine microvilli, like the pile of a carpet. It is obvious that large fat droplets cannot penetrate to the cell surface, but remain like marbles on the pile of the carpet; finer particles, however, may penetrate between the microvilli, like fine lead shot on a thick pile carpet. The limiting size for the particles to penetrate between the microvilli in the rat is said to be about 650 Å.[12] We had earlier assessed the critical size for particulate absorption as a diameter less than 0·5 μ; it would appear to be considerably less than this; of the order of 0·1 μ.

Emulsified Fat in the Intestinal Cell

Let us now turn our attention to the particulate fat in the intestinal cell. We have already seen that fat may be presented to the cell either as some water-soluble compound (this may be the major method for shorter chain fats), or in the form of a finely dispersed emulsion, which is the main form in which long chain glycerides are normally offered.[7] How do these fine particles enter the cell? There is some evidence, mainly based on electron microscopic studies, that they pass into the cell by a process of pinocytosis.[12] This certainly seems to happen, but whether it is a major or a minor part of the fat that is handled in this way remains unknown. Such a mechanism would seem to explain the absorption of paraffins and other water-insoluble oil-soluble substances in the presence of a suitable oil vehicle. We have, however, made some other observations which are less easy to explain. The addition of an oil-soluble silicone to a triglyceride does not lead to its absorption; the glyceride is absorbed, but the silicone is quantitatively rejected.[13] We are at present investigating the mechanism of this differentiation.

Once the fat is inside the cell it appears to lie in the endoplasmic reticulum. It is noticeable in preparations made of intestinal cells during fat absorption that the particles apparently increase considerably in size. This point was observed some years ago by Mottram, Cramer and Drew,[14] and they claimed that this formation of large droplets was due to vitamin deficiency and could be corrected by providing an adequate supply of vitamins A and B. We were not able to demonstrate any specific effect of these vitamins,[15] but it seems possible that the presence of other nutrients may be important and this requires further study. It is distinctly possible that the appearance of the fat loaded intestinal cell which is commonly called the classical picture of fat absorption is really an artifact resulting from the overloading of the cellular mechanisms by an excess of fat in the absence of other nutrients. It might also indicate relative inefficiency of the cell's clearing capacity.

Various changes happen in the passage of fat through the intestinal cells. The lower glycerides disappear and only triglyceride remains; phospholipids are formed, mainly phosphatidyl choline; short chain fatty acids (less than C_{10}) disappear from the lipid phase. These points will be further considered in the next section.

Finally the particulate fat leaves the cell. Electron microscopic studies reveal that the fat particles pour out of the sides of the cell.[12] It has been clearly shown, however, that the particulate fat does not pass from the intestinal lumen between the cells; no particles are seen between cells in the area towards the lumen, but they are plentiful towards the base of the cell. These fat particles are now loose in the interstitial spaces of the villus. It is quite clear that they pass preferentially into the lacteal; this is the blind end of the intestinal lymphatic system. The particles do not pass into the blood capillaries, which also abound in this area. This differential permeability of the lymphatic wall as compared with the capillary wall to these finely dispersed negatively charged fat particles is a matter of great interest. It is a fact that other negatively charged particulate materials, such as dyes or Indian ink, are similarly handled and, indeed, they are used for this reason to demonstrate lymphatic pathways. The reasons for this selective uptake are unknown, although some interesting suggestions were made by Clowes[16] many years ago; the problem seems worthy of further study. Whatever may be the mechanism, the fact is clear; the great bulk of the particulate fatty material absorbed into the interstitial tissue of the villi passes

into the central lacteal; then it passes into the intestinal lymphatic channels and so into the chyle.

The methods of studying the particulate fat in intestinal cells have already been indicated; various histological methods are available and, of course, electron microscopy. In animals the appropriate parts of the small intestine can be removed for examination. There are, however, a few points that may be mentioned. It is often helpful, if a measure of the amount of fat absorbed is made at the same time as the histological investigation; this can be done if a suitable method of recovery of the fatty material from the intestinal lumen is used. A combination of biochemical and histological studies will sometimes prevent mistakes. It is also important to look at the whole of the intestine and not just a small piece; this can be conveniently done using the so-called 'Swiss roll' technique.[17] With electron microscopy it is essential to get the tissue into fixative as quickly as possible; changes in mitochondria are apparent if fixation is delayed by about 10-15 minutes. So far as human studies are concerned, these are also possible by the use of modern biopsy techniques.[18,19] A good piece of small intestinal mucosa can be readily obtained by peroral intubation.

Emulsified Fat in the Chyle

The presence of finely dispersed fat in the chyle during fat absorption can be easily demonstrated by cannulation of the intestinal lymphatics or the thoracic duct. This has now become a widely used procedure in rats. Patients with a fistula of the thoracic duct yield similar information.

There are certain important differences between the emulsified fat studied in the intestinal lumen and the similar looking material recovered from the chyle. The main differences are shown in Table I.

It will be seen from Table I that the composition of the fats in the two emulsions is different, as already described. Of greater importance to this discussion is the change in the nature of the stabilizing interfacial film. The emulsion in the small intestine was essentially stabilized with fatty acid, lower glycerides and bile salts. It can be shown to behave as a negatively-charged emulsion in the presence of plasma proteins.[20] It is completely unaffected by the D lecithinase found in *Cl. Welchii* α-toxin.[21] The fat particles in the chyle, however, are different. They do not behave as simple negatively-charged particles in the presence of plasma proteins; if they did they would be agglutinated at normal blood pH. In fact, the particles show flocculation and precipitation reactions which are closely similar to those observed with globulins.[22] The addition of the D lecithinase from *Cl. Welchii* α-toxin causes rapid clumping and creaming of the fat emulsion found in chyle. It has, therefore, been concluded that the fat particles in chyle are stabilized by lipoprotein in which phospholipid, probably phosphatidyl choline under normal circumstances, is an essential component.

TABLE I

	Fat particles in:	
	Intestinal lumen	*Chyle*
COMPOSITION:		
Triglycerides	+	+
Di- and Mono-glycerides	+	—
Free fatty acids:—		
Long chain	+	+
Short chain	+	—
Phospholipids	—	+
FLOCCULATION PROPERTIES:		
Plasma protein at pH 8·4	+	—
D-lecithinase	—	+

Where have the fat particles acquired this lipoprotein stabilizing system? There are only two likely possibilities; either the lipoprotein is provided in the intestinal cells as the particles pass through them, or the fat particles are accommodated within the lipoprotein structure of the plasma when they enter the lymphatic system. There is no satisfactory evidence to decide this point at the present time although there are some reasons for thinking that the main site of modification is the intestinal cell.

We have been interested in the possibility of modifying this stabilizing system. In choline deficient rats, fat particles can be demonstrated in the chyle that are more resistant to D-lecithinase[11] and this may indicate substitution of another phospholipid or a different form of stabilizing system for these absorbed particles. We also found, on one occasion, abnormal particles present in a sample of human chyle obtained from a thoracic duct fistula; these were also resistant to D-lecithinase and had abnormal flocculation characteristics.[23]

All the fat in the chyle is not necessarily derived from immediately absorbed fat. This is clearly demonstrated when radioactive isotope labelled fats are fed. The dilution of immediately absorbed fat may be 50 per cent or more. This non-absorbed fat is presumably derived from the fat depôts and represents the continual turnover of adipose tissue.

Emulsified Fat in the Blood

The fat emulsion in the chyle is injected into the blood stream and gives rise to a temporary increase in visible particulate fat. The commonest form of systemic hyperlipaemia is that which follows absorption of fat—the alimentary hyperlipaemia. This can be studied in many different ways. A useful method is the chylomicrograph,[24] which is of particular interest in connection with our present discussion. Similar, but not identical, information is provided by the study of ^{131}I labelled fats, vitamin A absorption curves, or the study of optical density of plasma under controlled conditions.

Serial blood fat analysis can also be carried out. All these different methods show that after a moderately fatty meal, there is a marked increase of the particulate fat in the blood, which reaches a peak in 3-3½ hr. and subsides within 5-5½ hr. Analyses show that the change mainly affects the glyceride fraction, but that there are usually some slight concomitant increases in phospholipid and cholesterol; under ordinary circumstances these are not large changes and they tend to be inconstant.

What happens to this particulate fat? There is no doubt that it disappears from the blood stream and labelled fat studies indicate that it is partly oxidized and partly taken up into the adipose tissue cells.

Some light has been thrown on the fate of these fat particles by recent work on the heparin 'clearing factor'. This work started from a chance observation made by Hahn.[25] He observed that the administration of heparin to an animal caused a dramatic clearing of hyperlipaemia. This phenomenon has been extensively studied since then and we now know that the reason for the effect is the liberation into the blood stream of a lipase which acts on the circulating fat particles. This enzyme hydrolyses the glyceride and the resultant fatty acid is taken up by albumin. As hydrolysis proceeds the particles get smaller and smaller until eventually they cease to be visible.[26] This is, therefore, a mechanism for disposing of the circulating chylomicrons. My colleague, Warwick Brown,[27] showed that the administration of protamine to a fat-absorbing animal resulted in a more intense and prolonged hyperlipaemia and Jeffries[28] demonstrated the liberation of 'clearing factor' during normal fat absorption. These studies suggested that this enzyme might play a vital rôle in normal lipid metabolism. It probably is an important part of the mechanism, but it now seems probable that it is not normally liberated into the blood stream as after heparin injection. The hydrolysis of the glyceride is not an essential step for its removal from the blood stream or its entry into cells; it is merely a part of the mechanism, as in the intestine. Further research is needed fully to elucidate this problem of the removal of the fat particles from the blood stream; it seems likely that the 'clearing factor' lipase, which can be demonstrated in many cells, plays an important part.

Again the nature of the stabilizing film on the particle may be important. Korn[29] has shown, using the 'clearing factor' lipase from the heart muscle, that particles are only acted upon by the enzyme if they are stabilized with lipoprotein. He has consequently given it the name 'lipoprotein lipase'. It is possibly of interest that the particles found in the chyle in choline deficient rats are relatively resistant to lipoprotein lipase.[11]

A further observation on the importance of this stabilizing film may be mentioned. If a chylomicron emulsion, that is to say fat particles stabilized with a lipoprotein film, is injected into the blood stream, the fat particles are evenly dispersed in the liver and other tissues. They appear to be fairly easily taken up into the liver parenchyma cells. If, however, a similar artificial emulsion is given, in which the fat particles are differently stabilized, say with dextran, the fat is not evenly distributed and the particles do not appear to pass readily into the liver parenchyma cells; instead they are seen to be largely taken up by the reticuloendothelial cells, such as the Kupffer cells in the liver.[23] It appears, therefore, that the body cells can differentiate between these two types of particle; it is difficult to escape the conclusion that this differentiation is dependent upon the different chemical and physical properties of the stabilizing interfacial film.

A condition is known, called essential hyperlipaemia, in which the alimentary hyperlipaemia does not clear normally. In these patients the emulsified fat in the blood tends to accumulate. This usually causes no symptoms and the condition is discovered accidentally when blood is taken for some other reason. I saw such a patient a few years ago who had 18 g. of fat per 100 ml. of blood! At the present time we are in touch with two or three patients of this type with blood fat levels in the region of 10 g. per 100 ml. Such a patient was studied by Thanhauser[30] using ^{131}I labelled fat; he showed very clearly that there was a delayed rate of removal of the particulate fat from the blood stream The situation rapidly improves in such patients if they are placed on a low-fat diet and this is all the treatment that is necessary in most cases. From the point of view of mechanism, it is obvious that there are at least two possibilities. The patient may have some abnormality of lipoprotein lipase, if this enzyme is indeed concerned in removal of fat from the blood stream, or it may be that the fat particles have some abnormal structure and are consequently resistant to the action of lipoprotein lipase. Such studies as have been done in patients with this rather rare condition suggest that both these types may exist. It is, of course, possible that entirely different factors might also be involved.

There are, of course, other forms of hyperlipaemia. Those due to mobilized fat may be studied in starvation or following administration of certain hormones. Ether anaesthesia may give rise to hyperlipaemia and it may also be observed in rabbits after repeated bleeding. There is no clear evidence, at present, to suggest that the emulsions concerned differ fundamentally from those observed in alimentary hyperlipaemia; they have not been so extensively studied, however, and might repay further examination.

The *in vivo* emulsions considered here by no means exhaust the subject. The formation of milk in the mammary gland is another excellent example of *in vivo* emulsification and the stabilizing system used is different from those I have discussed. Again, fine emulsification often occurs in the crop of birds and this 'milk' is in fact used for feeding the young. We have, also, confined our attention to oil-in-water emulsions; phase inversion may, however, be involved in the overall picture in the body. These are matters, however, on which little information is at present available.

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BOOK REVIEWS

The Advance Science Master's Handbook, compiled by Ivan L. Muter, B.Sc., A.M.I.E.E., A.Inst.P. Essex: Advance Components Ltd. 1960. pp. 124. 12s. 6d.

The publishers of this book, who are electronic instrument manufacturers, point out that many science masters in 'Modern' Schools experience difficulty in demonstrating the theory taught during their lectures. Consequently the company commissioned the author to prepare a handbook setting out a series of experiments covering general electronics theory and sound and wave motion, together with miscellaneous data, which replace separate data sheets previously supplied.

It should be emphasized that the title of the publication is misleading as the chemistry master, the biology master and even the physics master teaching to 'O' level will have no use for this book. Secondly the expression 'Modern' School does not refer to Secondary Modern or other such schools but to such establishments as may be teaching modern physical subjects.

The book is divided into two sections. The first, entitled 'Electrical Circuit Theory, Basic Electronics and Reference Data' deals with thermionic valves, power supply units, transistors and the velocity of sound in different media. The object of this part is to give only essential formulae and definitions for the experimental work described in the second section. An understanding of physics at at least 'A' level is required to comprehend the subject matter.

Part Two describes a series of 47 experiments and demonstrations which, it is stated, can readily be set up from the resources normally available in the school laboratory, and deals with a.c. circuit experiments, electronic measurements, valve experiments, measurements on radio receivers and sound and wave motion experiments. These experiments are described concisely, clearly and with excellent diagrams and pupils with sufficient grasp of the subject should find the publication of great use when implemented by lectures.

This book, however, although excellent for use in Technical Colleges, must have a very restricted use in schools being suited only to third year VI form pupils who are considering taking up electronics as a career.

C. B. TAYLOR.

Elementary Titrimetric Analysis, by A. M. G. Macdonald, Ph.D., A.R.I.C. London: Butterworths Scientific Publications. 1960. pp. 133 + viii. 12s. 6d.

In the Preface the author makes a point that most of the existing text-books on volumetric (titrimetric) analysis are out of date and that his book should be of use in schools and junior technical colleges. Most teachers of chemistry in these spheres would, no doubt, agree with the first part of this statement and consider that it does not apply only to analytical chemistry. The teaching and practice of volumetric analysis in schools applies only to those pupils who are taking the Advanced Level of the G.C.E. and the pressure of the syllabus frequently does not allow them to carry out much more than simple acid-base titrations, the use of potassium permanganate, iodine and other straightforward procedures. The problem facing the author in the preparation of a book with the existing title is to introduce the pupils to the best possible techniques with emphasis on accuracy and cleanliness together with lucid theory of the chemical reactions which take place. Only too frequently does the pupil, both in qualitative and quantitative analysis, carry out the practical work without any clear understanding of the theory.

The author has certainly strived to produce a book which combines practice with theory. There are six chapters, which include description and maintenance of equipment, acid-base titrations, argentimetric methods, redox titrations and complexometric titrations. The book commences in a suitable elementary fashion to describe the burette, its use and care (although it is doubtful whether beginners should be allowed to use 'Vaseline' on stop cocks), the pipette, measuring flask and the measuring cylinder; a diagram of the latter would appear to be superfluous. As this book is so clearly an introduction to the subject a brief description of the chemical balance and its use would have been a useful addition and it is somewhat surprising that there is no mention or account of procedures for testing the accuracy of the burette.

In Chapter III, the beginning of the serious matter

of titrimetry, the reader is at once faced with the line 'In the Bronsted-Lowry theory of acid-base reactions'—but referred to appropriate text-books on physical chemistry to read the theory. In view of the excellent and detailed theory which is found throughout the book it seems a pity that some space could not have been found for the Bronsted-Lowry theory as the theory is either not mentioned at all or treated very scantily in several of the commonly used text-books intended for the 'A' level examination. Indeed after reading this book one is once more reminded of the urgent need for text-books in all branches of school and technical college chemistry which are as well planned and clear as this one. The steady reprinting of old out-of-date text-books is a backward step to both teacher and pupil.

The book continues in excellent fashion and deals well with dissociation ('although *reasonably* dilute' is perhaps, slipshod), ionization, pH values, indicators and neutralization curves. Redox equations are made extremely clear and pupils should be able to understand such essential principles as the balancing of electrons. The book is well produced and easy to read and the author should be congratulated on writing a really modern book, unhappily however only a very small proportion of the subject matter can possibly be covered in most schools.—C. B. TAYLOR.

Progress in Industrial Microbiology, Vol. 2, edited by D. J. D. Hockenhull, M.A., Ph.D., M.I.Biol., London: Heywood & Co. Ltd. 1960. pp. 194 + vii, 45s.

There has recently been a spate of new books reviewing recent and past work on industrial fermentations and related techniques. From the reader's point of view it is perhaps unfortunate that such reviews could not all be included in one annual publication, but this obviously will not now happen.

The second volume of 'Progress in Industrial Microbiology' maintains the high standard of the first. It is divided into seven chapters on completely different subjects by different authors. The first chapter, by J. G. Davis, is the first part (with more to follow in a later volume) of a review on 'The Lactobacilli'. It is written in a light style and is a review article on recent work, dealing particularly with problems of classification. The author's statement that 'decisions as to what constitutes a species are more a function of the human mind than an accurate determination of a fixity in nature' illustrates his approach to the problem.

The next chapter is by V. A. Knivett on 'The Microbiological Production of Vitamin B_{12}, and Sulphide from Sewage', and is again a review of recent papers, though the part dealing with sulphide production deals largely with work with which the author has been directly concerned. Similarly, J. Postgate writing on 'The Economic Activities of Sulphate-reducing Bacteria', is largely summarizing work carried out by the now defunct Microbiology Department of the Chemical Research Laboratory, of which he was a member. He has produced a most useful survey of the largely deleterious activities of these ubiquitous organisms.

The fourth paper is an unusual one to find in such a setting. J. P. R. Tootill of Glaxo Laboratories writes on 'Non-linear Problems in Statistical and Mathematical Interpretation', and deals with the evaluation of the Michaelis constant in systems where biological or other imprecise assay methods are employed, with microbiological recovery assays, and with the analysis of counter-current distributions. In that the last of these has no particular direct biological interest, it is surprising to find it included.

R. Elsworth discusses 'Developments in Fermenter Design and Fermentation Control'. This chapter is a mixture of a review article with much information obtained by the author and his colleagues at Porton. Subjects particularly stressed are vessels for continuous culture, both on a laboratory and pilot plant scale, sterilization, aeration, and pH control. Then follows a very full review by the Editor of the literature for the last 15 years on 'The Biochemistry of Streptomycin Production', dealing in particular with the effect of varying the medium constituents. This contains also much of the author's own work.

The final chapter by D. Perlman and C. J. Sih is on 'The Fungal Synthesis of Citric, Fumaric and Itaconic Acids' This is almost entirely a review article and shows up at a disadvantage to the others in that it covers the literature widely but not critically, and does not differentiate the important papers from the great mass of less interesting ones. One has the impression that the authors have not recently worked on the large scale production of these acids, and are not fully conversant with the problems involved.

Taken as a whole this is a most useful volume, recommended to all workers in industrial microbiology.

—L. M. MIALL.

Inorganic Chemistry—A Guide to Advanced Study, by R. B. Heslop and P. L. Robinson. 1960. Amsterdam: Elsevier Publishing Company. London: D. Van Nostrand Co. Inc. pp. 555 + viii. 45s.

Anyone who was taught inorganic chemistry in the days when the world's biggest and best explosives were made from organic not inorganic chemicals, must have realized that with the release of new knowledge accompanying that fateful day in 1945, his own schooling in nuclear structure and the Periodic Table would be definitely incomplete. The main purpose very ably served by the present work is to teach its subject on the basis of modern nuclear theory.

The first 10 chapters of this book provide a modern general chemical treatment while the remaining 28 are concerned with individual elements. The number of fundamental entities is now as high as 16, however in understanding the structure of the atom one is still primarily concerned with the proton, the neutron and the electron. Treatment of the atomic nucleus now includes such matters as stellar energy and the use of the atomic pile. Considerable treatment is given to wave mechanics, a science which has of course by now been

recognized as essential to the understanding of the behaviour of the electron. However in spite of the need today for a chemist to understand probability and uncertainty, a pictorial representation of solid electrons in definite orbits is still in general use. It is of interest that the authors, in accordance with their general approach to their subject do not hesitate to use organic compounds to illustrate their text and to include chapters on chemical thermodynamics and kinetics.

After such thorough preparatory work one might well enquire as to what the book teaches of the chemical properties of elements and compounds. It has long been considered altogether too naive and quite the wrong approach to inorganic chemistry to list each compound and record its properties. The alternative treatment by groups is of course admirable for the student but hard on the chemist who, using a book for reference, suddenly wants to know everything possible about say aluminium chloride and has to collect his facts from a mass of dispersed references. The present work is fairly compact in this respect and search within is aided by the numerous sub-titles. Although the amount of data offered is limited by the size of the book, full use is made of modern knowledge, e.g. hydrogen bonding to explain the structure of boric acid and hybrid orbitals to explain the structure of nitrous oxide. Needless to say those recent arrivals, the trans-uranium elements, are dealt with in the text, the naming of some of wnich will doubtless seem very odd to chemists who have not yet learnt of their discovery.

This is a very readable book and does not have to be read from the beginning for any one chapter to be understood. Above all it does much to show how inorganic chemistry has completely recovered from the second place it occupied when organic synthesis was supreme.—A. S. FREEBORN.

Trace Techniques using the K.1000 Cathode Ray Polarograph, Vol. I, by J. Hetman, F.R.I.C. Surrey: Southern Instruments Ltd. 1959. 25s.

This book is a collection of 30 methods, developed by the author, for the determination of trace constituents and impurities in a wide variety of materials. There is no suggestion that it is in any way a text-book of oscillographic polarography, but it is simply intended as a collection of methods for direct application to specific problems in a routine laboratory.

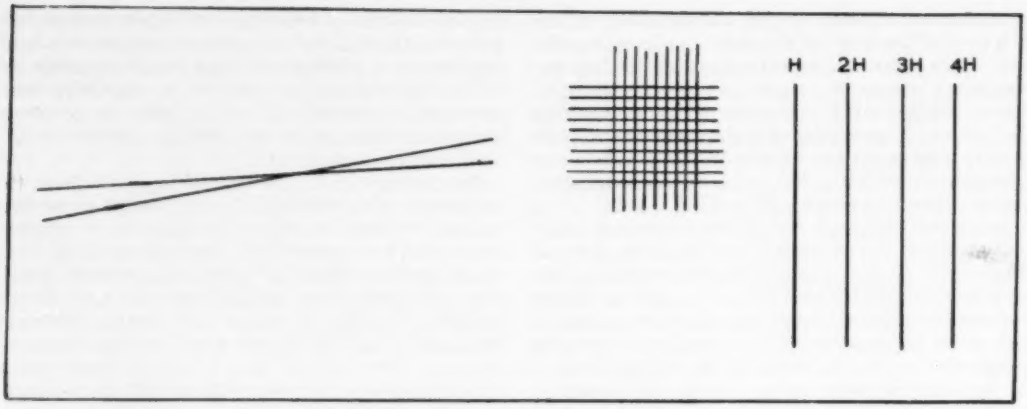
Inorganic and organic substances have both received attention and a number of the methods contain novel features. They include procedures of interest to food and public analysts, such as the determination of vitamin C in fruits and fruit juices, saccharin in non-alcoholic drinks, arsenic in plant materials, lead (in the presence of copper) in cocoa, traces of cyanide (less than 1 p.p.m.) in water and iron in blood serum and liver. Metallurgical methods include the simultaneous determination of copper, lead and zinc in manganese brass, copper and lead in leaded steel, lead in brasses and bronzes and the simultaneous determination of beryllium, aluminium and lead. Those concerned with the plastics industry are the simultaneous determination of fumaric and maleic acids, the determination of p-chlorobenzyl cyanide in a polymerization mixture and trace metal impurities in P.V.C. There are also methods for explosive and pyrotechnic materials. A bibliography giving some background information and references to methods of allied interest is appended.

The methods are in note form giving, in addition to brief details of procedure and interpretation of results, essential information such as preparation of sample, base electrolyte constitution, reference electrode employed and recommended instrumental settings. Specimen polarograms are included in each case. These methods are easy to follow and contain sufficient information for direct application to the specified problems. Their brevity and the lack of background information, however, may make it difficult to adapt them for use in similar analysis of slightly different materials and may cause some confusion to the non-specialist in certain cases. In addition the very high sensitivity and low levels of detection, which can be achieved by this technique, have not been sufficiently emphasized and have to be inferred from the specimen polarograms and concentrations in the calibration solutions.

A number of errors are present, but these are mainly terminological and do not seriously affect the procedures given. The most persistent is the use of 'basic' instead of 'base' electrolyte, which is an error sometimes encountered in papers in English in foreign journals. The heading 'Basic Electrolyte' is itself somewhat misleading, since the materials listed under it in several methods do not have this function. It is also incorrect to refer to the current flowing at the peak of the wave as the 'diffusion current'. The current at this point is not diffusion controlled and it is more usual to use the term 'peak current'.

The book starts rather abruptly with only a short Foreword. The inclusion of an Introduction, setting out the author's objectives and giving some theoretical background would have been a great improvement, especially if the advantages of cathode ray polarography had been outlined. The omission of this is not important to the specialist, but it would have helped the non-specialist and routine user (at whom the book is presumably aimed) to realize this is not concerned with a new method involving special and exclusive principles, but with an advance in polarographic instrumentation offering greatly increased sensitivity and rapidity of operation.

No collection of methods for a single polarographic technique has previously been published in this way and the author must, therefore, be regarded as a pioneer. He is likely to receive the compliment of imitation. In spite of the limitations mentioned above, none of which has any serious effect on its practical value, the book will be very useful to the routine analyst. Polarographers and analytical chemists in general will also find that it contains much valuable information which is applicable outside its present field.—G. F. REYNOLDS.



Panel showing adhesion and hardness tests.

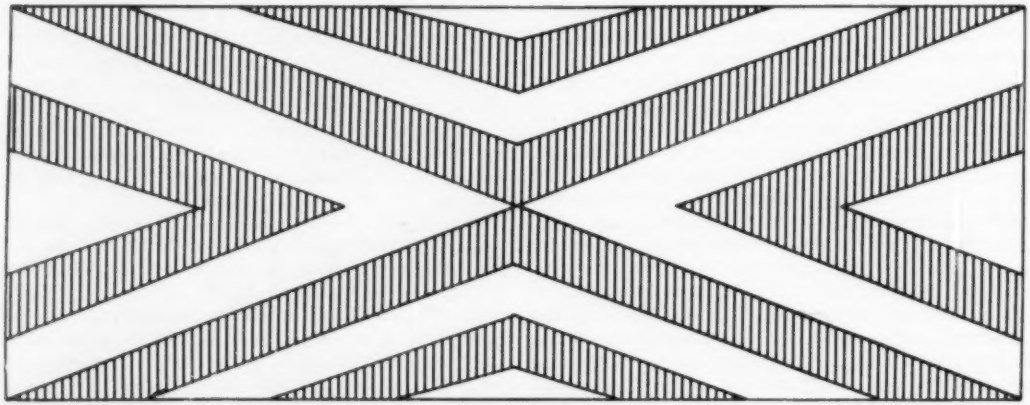
RAPID PAINT EVALUATION

by A. J. Easton, A.I.S.T.

A NUMBER of industries use painted finishes on their products and a rapid evaluation of the finished surface is required, particularly in those cases where the articles involved are mass produced. The tests to be described do not require the more expensive equipment used by paint manufacturers, where detailed colour matching and refined testing are desired. The good adherence of the paint film to the article or to the primer coat is most important and this may be tested by two methods.

In the first of these a minimum of 12 parallel lines are scored by a steel scrib each one-sixteenth of an inch apart. The surface is now rotated through 90 degrees and another set scored the same distance apart. The scrib should be rotated between the fingers as each line is scored to maintain a sharp point. The adherence is measured by the amount of paint that is chipped away at the intersection of each line with that at 90 degrees to it. A good adherence will have 95-100 per cent of the paint left intact on the test area.

The second method consists of scoring two intersecting lines six inches long having a gap of one-eighth of an inch at each end of the lines. The adherence here is measured by the length of paint removed from the point of intersection. Both sides are measured, thereby giving a double check. As before, the scrib should be rotated during the scoring of the lines. Careful examination of the article after removing the paint lifted by the test will show any tendency towards weakness by the primer coat if one has been applied. Good adherence in this test will be shown by less than one quarter of an inch being removed from the point of intersection of



Panel for evaluating gloss.

the two lines and slightly less than this length of the primer coat.

The next test of importance is the hardness of the finish coat and this is most easily done by drawing a line with a freshly sharpened lead pencil of known hardness, the point of which has been slightly rounded by very fine emery paper. Pencils of increasing hardness are used until, when the pencil mark is wiped off with a rag, an indented line is visible. The hardness of this pencil is then noted. For most articles a value of from 2 to 4 H is found satisfactory for normal handling.

A property which will vary in importance with the ultimate use of the article is the flexibility. This is best tested by applying the same paint as used on the article to a thin sheet of the same metal, the surface being prepared in a similar manner, e.g. zinc phosphate, chromate, etc. When the article is fairly solid, for example a stool top or fan base, etc., this test is of little importance, but if the article is large in area and constructed of thin sheet, the factor of flexibility will affect the ability of the article to withstand impacts. The test sheet is bent over double a half an inch in diameter mandrel and the subsequent extent of cracking noted. A better test is using a conical mandrel ranging from one-eighth of an inch up to one inch in diameter, for it is possible by using this latter type of mandrel to note at which diameter the paint film begins to split.

The colour is best tested in a simple wooden box, painted a matt white, with the opening facing the operator, using either a blue daylight filter or a 'daylight bulb' inserted in the top for illumination. Colour standards should be prepared when the colour first meets the requirements and stored subsequently in a box away from daylight unless being used for testing, as most paints exhibit fading in the presence of ultra-violet light.

Gloss may be evaluated by the use of a white painted or enamelled plate on which one half-inch wide black tape is attached either in chequered or diagonal V shaped patterns. The definition of the image, i.e. the sharpness of the reflected black strip is a measure of the gloss. This test is particularly useful where weathered test panels are being examined and may be used generally for white or coloured finishes.

These various tests used on a routine basis give a useful comparison of day-to-day productions and can detect obvious deviations in quality. It will be appreciated that with these types of test the continuity is best maintained by the same person performing them daily or weekly as required. The colour and gloss tests are of most use where separate components are painted in batches and are subsequently assembled. The finish on any article should be the best that is economically possible as the appearance is often important to sales promotion in addition to being an insurance against corrosion.

REPORT

GLASS TECHNOLOGY FOR EXPERIMENTAL GLASSBLOWERS

THE tenth one-day Colloquium on Glass Technology for Experimental Glassblowers was held by the Ministry of Aviation in London on Thursday, October 13. The following programme had been arranged by Mr. I. C. P. Smith, B.Sc., F.S.G.T. Three talks followed by discussion:

'Ultra High Vacuum' by Dr. J. C. Riviere of A.E.R.E., Harwell.

'Annealing' by G. D. Redston, M.Sc.(Tech.), of Brinkman (Sales) Ltd.

'Strain Viewing' by B. Sugarman, M.Sc., D.I.C., F.Inst.P., of the British Glass Industry Research Association.

'Schlieren' a colour film made by Shell-Mex and B.P. Ltd.

In the unavoidable absence of Dr. Thorley-Lawson, Mr. Vaughan deputized for him and opened the meeting. The Chairman was Mr. I. C. P. Smith.

Dr. Riviere started his talk by explaining that the production and use of ultra high vacuum was a technique of comparatively recent origin, having started about ten years ago. Until last year all-glass systems were essential, but now metal systems were being used. All glass which is to be used in these systems must be very well cleaned before assembly.

He defined, in millimetres of mercury pressure, 10^{-3} to 10^{-7} mm. as high vacuum, 10^{-7} to 10^{-9} mm. as very high vacuum, and below 10^{-9} mm. as ultra high vacuum.

The reason for desiring such low pressures in systems was that, in much experimental work, in solid state physics for example, a 'clean' surface was necessary on the material being studied. The time taken for a monomolecular layer to form on a clean surface increased as the pressure in the system was lowered. For example, at a pressure of 10^{-10} mm. this time would be about three hours and would provide a reasonable period in which to carry out some experiments. In some cases, a much longer time would be needed and therefore a lower pressure was essential.

The system needed to obtain these very low pressures consists of a mechanical vacuum pump, backing two glass diffusion pumps in tandem, and a liquid air trap or traps of low impedance. A suitable design of glass diffusion pump is the well-known design of Bull and Klemperer[1].

The ultra high vacuum section beyond the traps needs to be baked to a temperature of 540°C. for about 10 hours to complete the outgassing. This section consists of a glass connecting tube, to be subsequently sealed off, an Alpert[2] gauge or the gauge developed by

Alpert and Bayard[3] and the vessel being evacuated. If any part of this section is made of stainless steel then before incorporation in the system it needs to be outgassed in an inert atmosphere at a temperature of 750°C. Instead of a glass connecting tube to be sealed off, a bakeable metal tap may be used; these taps consist of a steel or hard metal portion which is pressed on to a soft copper seating to effect a cut off. Successive use work-hardens the copper seating and renders the tap ineffective. The baking process helps to soften the copper but even so the life of these taps is usually limited to about 100 operations. See for example D. Alpert[4].

Other ion pumps were described by Dr. Riviere, the Getter-ion-pump which is a development from the Penning gauge[5] and is suitable for pressures down to 10^{-9} mm., and the pumps developed by R. G. Herb[6] and his co-workers, known as Evapor-ion-pumps, which utilize repeatedly evaporated titanium metal.

A reason why the mercury vapour diffusion pump will not attain these very low pressures is because of the outgassing of the glass of which it is made. A recent design of pump by Venema and Bandriga[7] overcomes this difficulty by being constructed in such a way that it can be baked.

Many questions were asked at the conclusion of the talk and a lively discussion ensued. A great deal of useful information about cleaning of the glass, sealing off from the pumps and designs of all glass valves, was exchanged. (See below for references to this paper.)

Mr. Redston started his talk by saying that although it is always necessary for glass articles to remain in one piece during their useful life, there are often further requirements; telescope mirrors must not distort by changing shape with time, and refractive index of optical components must not change. The study of the annealing process and the degree of complexity of the equipment involved depends on the ultimate aim. For lampworked ware the only important aim is that it shall not crack in service.

The decay of the strength of glass under continuous load is well known.

Time	*Kilograms per square centimetre*
1 sec.	920
1 min.	680
1 hr.	550
1 day	490
1 month	440
1 year	410
1 century	380

These values clearly show that if glass articles are loaded to about half the amount necessary to break them almost immediately, there is a strong chance that they will break during a reasonable working life. Therefore it is advisable to design glass articles to be subjected to loads less than 1/10th of 400 kg. per sq. cm. i.e. 40 kg. per sq. cm. If a glass article is imperfectly annealed there is a built-in stress, and it is as important to keep this to a safe value as it is to ensure that any externally applied stress is also kept to a safe value. Saying that stress can be defined as force per unit area, and strain as a change in dimensions, per unit dimension, Mr. Redston showed by means of simple calculations that temperature differences between different parts of a glass article can cause large stresses to be developed.

The purpose of the annealing process is to reduce any built-in temperature differences to low values so that the built-in stresses in the article are kept within a good factor of safety of the long-time continuous loading strength of glass. The sequence of sections in the annealing process is:

1. Heat fast.
2. Hold at temperature at which stress is relieved.
3. Cool slowly until the glass is rigid.
4. Cool faster.
5. Cool at top safe speed.
6. Hold at room temperature.

He then explained in some detail the changes undergone by the glass during the time it is in each section.

A high 'holding temperature' means a rapid stress release but a long period of cooling before the glass becomes rigid enough to allow the cooling to be accelerated. A low holding temperature means a quick attainment of rigidity but a long slow stress release. The shortest annealing schedule finds the best balance of these two conditions.

The lampworker often anneals his wares by cooling them in a soft gas flame and although this seems a very 'hit-or-miss' procedure, theory justifies this method. This schedule is, in effect, holding for a very short time at a very high temperature and then cooling uniformly, but fast.

Mr. Sugarman described the principles of strain detection in glass. Strain free glass is isotropic so that light travels through it at the same speed in all directions and the emergent ray is unchanged in direction. Brewster about 1816 discovered that transparent isotropic materials become optically anisotropic when subjected to mechanical stress. Glass under stress behaves in this manner. When a ray of plane polarized light enters strained glass, it is broken into two polarized rays vibrating at right angles to each other. When glass is subjected to simple compression or tension one ray always vibrates in the plane which includes the axis of the stress and as its velocity through the glass varies with the inclination of the incident light it is known as the extraordinary ray.

[1]Bull and Klemperer (1943). Jour. Sci. Insts., **20**, 179.
[2]New developments in the production and measurements of Ultra High Vacuum (1953). Jour. Applied Physics., **24**, 860.
[3]Bayard and Alpert. (1950). Rev. Sci. Insts., **21**, 571.
[4]D. Alpert (1951). Rev. Sci. Insts., **22**, 536.
[5]Penning (1937). Phillips Tech. Review, **2**, 201.
[6]Divatia, Davis and Herb. (1953). Phys. Rev., **93**, 926.
[7]Venema and Bandriga (1958). Phillips Tech. Rev., **20**, 145.

The other ray vibrating in a plane at right angles to that of the extraordinary ray travels through the glass at a constant velocity irrespective of its angle of incidence and is known as the ordinary ray. The difference between these two rays is at a maximum when the incident light is at right angles to the applied stress and it gradually decreases to zero as the incident light becomes parallel to the direction of the stress. Plane polarized light is therefore double refracted when it passes through strained glass, unless its direction is parallel to the direction of applied force in which case it passes through the glass unchanged. Use is made of this double refraction to determine the state of strain in glass by measuring in a polariscope the lag or retardation of one ray behind the other. A polariscope or strain viewer consists of: a source of white light, a polarizer and a second polarizing device known as an analyser. When the polarizer and analyser are set with their planes of polarization at right angles to each other no light passes and only a dark field is visible. When strained glass is placed between the polarizer and analyser light is transmitted and the effects observed (various colours) are used to estimate the amount of strain.

As a rule the phase differences produced in strained glass are less than 260 mμ, so a tint plate made of some birefringent material, such as selenite, is used to increase the sensitivity of the strain viewer. The thickness of the tint plate is adjusted so that it has a retardation of 565 mμ, but this retardation may vary from tint plate to tint plate, so that in different strain viewers the same piece of strained glass would exhibit different colours.

A method of standardization was to compare a test piece strained to a known degree with the glass being examined. There was available for this purpose a set of five discs each one producing a retardation of 22·76 mμ. For the precise determination of strain the retardation must be measured with a compensator of the Babinet or Berwick type. Mr. Sugarman concluded his talk by briefly mentioning the use of specimens of plastics materials with frozen-in stress patterns for photoelastic studies. (See below for references to this paper.)

'Schlieren'

The Schlieren method, due to A. Toeplar, is a method of exhibiting inhomogeneities in transparent media, for example striae in glass, and convection currents in liquids or gases. This film in colour showed many examples from the mixing of liquids to supersonic flow.—J. A. FROST.

The Use of Standard Discs in the Strain Testing of Glassware. E. J. Gooding (1938). Jour. Soc. Glass Tech., 24, 186.
Preparation of the British Model of Standard Strain Discs. A. J. Holland (1945). Jour. Soc. Glass Tech., 29, 148.

The Perkin Centenary Trust

Mauveine, the first important synthetic dye, was discovered by William Henry Perkin in 1856. This discovery marked the birth of the dyestuffs industry and of the greater part of the organic chemical industry of the world. The centenary of this historic event was commemorated in 1956 by celebrations that were widely supported by many organizations having an interest in chemistry. The Perkin Centenary Trust was established as a lasting memorial of this occasion, and to promote technical education in all aspects of the manufacture and application of colouring matters.

Applications for the following awards should be made on forms available from the Secretary, and must be received not later than May 1, 1961:

The Perkin Centenary Fellowship.—This award is offered for one or two years for the purpose of higher study of any subject approved by the Trustees. Candidates will be required to show *either* that they have had experience in an industrial firm or other institution concerned in the manufacture or the application of colouring matters, *or* that their intended field of study has a direct bearing on these subjects. The value of the Fellowship is £750 per annum with an additional grant of up to £100 per annum towards certain designated expenses. It may be tenable from October 1961, at any university, technical college or other institution approved by the Trustees.

The Perkin Centenary Scholarship.—Two such awards are offered, each for two years, renewable at the discretion of the Trustees for one further year, to enable candidates employed in an industrial firm or other institution concerned with the manufacture or the application of colouring matters to receive an education at a university or technical college. Each award will have a value of £350 per annum. This may be increased, at the discretion of the Trustees, to £400 per annum if the candidate appointed is required to live away from his normal place of residence. There is no means test and a successful candidate is not debarred from receiving the whole or a part of his normal salary from his employers during his tenure of the Scholarship.

Perkin Centenary Trust Travel Grants.—Applications are invited from teachers concerned with the study of any aspect of the manufacture of the application of colouring matters at a university, technical college, or other institution. The purpose is primarily to assist those for whom grants are not readily available from other sources. Each application will be considered on its merits. The Trustees, however, expect that preference will be given to applications from lecturers, senior lecturers and readers, or the equivalent grades in other institutions, wishing to gain experience at a similar institution or in industry overseas. The object of the intended visit must be clearly stated (e.g. study of special techniques, apparatus, or industrial processes: to assist in some stated research project; or to study some specific educational method) and the applicant will be expected to devote sufficient of this time to that object so that effective study is possible. Grants will be available towards the cost of travel and maintenance for periods, related to the purpose of the visit of from one to three months.

PHYSICAL SOCIETY EXHIBITION

The January Issue of Laboratory Practice will contain a preview of exhibits to be seen at the New and Old Horticultural Halls from January 16th to the 20th.

A TIMING UNIT FOR NUCLEONIC COUNTING

by W. G. Duncombe, B.Sc., Ph.D.

The Wellcome Research Laboratories, Langley Court, Beckenham, Kent

THE apparatus to be described here was designed for the time control of a scaler (Isotope Developments, Ltd.; Type 500/A) used for radioactivity measurements. Commercial timing units for this purpose do not all have a sufficiently wide choice of times and the present one was made with a range of one minute to more than one and a half hours. It can also be used for controlling an automatic sample changer (to be described later). The circuit makes use of electromagnetic components, mostly obtained from Government surplus sources, and the principle could obviously be adapted for timing purposes other than that considered in detail here.

The general principle of operation is as follows. A contactor delivers a pulse every minute to the coil of a uniselector, causing the wiper arms to move on by one step. After the required number of minutes, preselected by a switch, the wiper arms close circuits which stop the scaler and reset the uniselector to its 'off' position. The timer will then not operate again until the scaler has been reset, either manually or by a signal from the automatic sample changer.

Construction

The uniselector is of the standard semi-circular pattern, and has eight banks, each of 25 contacts, the wiper arms being connected so as to give four separate banks each of 50 contacts (*see* Fig. 1, in which for clarity each bank is shown as a straight row of contacts). Bank I is used for the uniselector resetting circuit, banks II and III for the time selecting circuit and bank IV for switching from II to III, giving a total of 100 positions for time selection.

A simple unsmoothed transformer/metal rectifier circuit provides 24 volts D.C. at 4 amps. for operating the uniselector and the relays, and also for the automatic sample changer. The maximum current taken by any component is about 200 mA. so that any type of quick-acting relay having a suitable arrangement of contacts capable of controlling this current would be suitable. In the author's instrument, both heavy-duty contact and P.O. type 600 relays are used and have given no trouble in two years of regular operation.

The detailed circuit is shown in Fig. 1. Contact banks II and III constitute the time-selecting circuit. The first contact of II is not connected, the second corresponds to zero time (start of timing period) and subsequent contacts correspond to consecutive minutes. These contacts are taken *via* two-way switches to two circuits X and Y. When connection is made to an X contact the scaler will count; on connection to a Y contact the scaler is stopped and the timer is reset ready for the next counting period. In practice only those contacts corresponding to the more often used

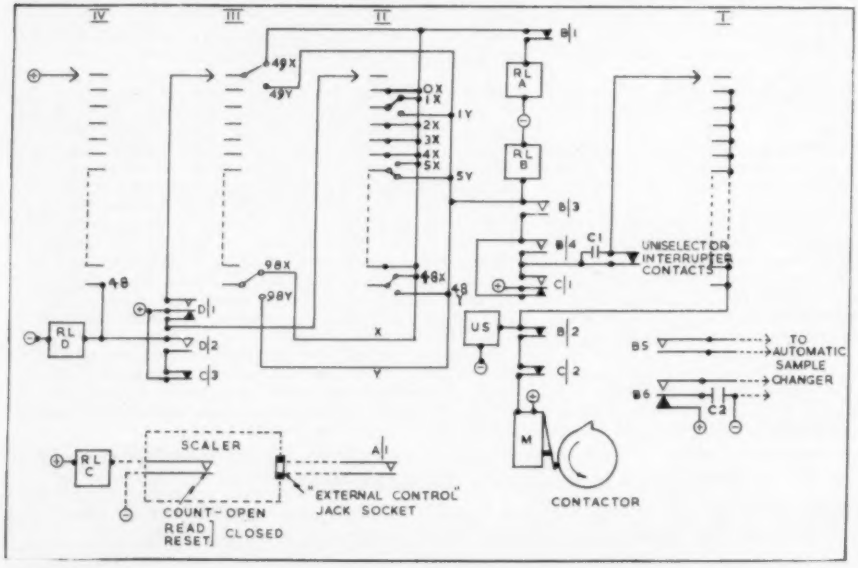


Fig. 1 Circuit diagram of the timing unit. C1, 0·1 μF; C2, 1000 μF; M = microswitch; RL = relay operating coil.

time intervals (1, 2, 5, 10, 15, etc. minutes) are thus connected, the remaining contacts being permanently connected to circuit X. The two-way switching is carried out by mechanically inter-connected push buttons, so that normally all contacts are connected to circuit X and only one contact at a time can be connected to circuit Y when the appropriate button is pressed. For clarity, in Fig. 1 only a few representative connections to the contact banks are shown.

The timing pulses are provided by a contactor consisting of a Perspex cam, driven by a continuously running synchronous motor at 1 rev./minute, which closes a micro-switch (Bulgin S. 530/L/RP). The shape of the cam (Fig. 1) is such that the micro-switch circuit is closed fairly slowly but broken very rapidly. The uniselector coil is energized on 'make' but the ratchet mechanism does not actually move the wiper arms until the circuit is broken, so that the wiper arm movements, marking successive minutes, occur at reproducible intervals. If required for much shorter or longer time periods a synchronous motor of 1 rev./sec. or 1 rev./hr. could be substituted.

A small modification was necessary to the scaler. As shown in Fig. 1, a spare position on the 'reset' relay was connected so as to actuate relay C. Control of the scaler is effected by contacts of relay A being connected to the 'external control' jack socket of the scaler, which will count only when this circuit is closed.

Operation

Suppose that the scaler has completed a count and has been reset and switched to 'count'. Then all relays, A, B, C and D are in their normal (not energized) states and the wiper arms of the uniselector are in the 'off' position as shown in Fig. 1. Also suppose that a time period of five minutes has been selected for the next count. Then on bank II the five-minute contact is connected to circuit Y via 5Y, all others being connected to circuit X.

On the next operation of the contactor micro-switch the uniselector coil is energized (via relay contacts C/2 and B/2) and the wiper arms move on by one step. That on bank II switches 24 V (from D/1) to circuit X (via contact OX), which energizes relay A so that A/1 closes and the scaler starts counting. On each of the next four pulses from the contactor the wiper arms move on by one step, the circuit X being kept closed via contacts 1X, 2X, 3X and 4X. On the fifth pulse, however, the 24 V supply is connected to circuit Y (via 5Y), energizing relay B. At the same time circuit X is broken, de-energizing relay A, so that A/1 is opened and the scaler stops counting. The operation of relay B opens B/1 (to prevent resumption of counting while the uniselector is resetting) and closes B/3 and B/4, whereby current is supplied (via C/1) for holding relay B in the energized state and for resetting the uniselector automatically to the 'off' position (via the interrupter contacts and the resetting bank I). At the same time, B/2 is opened to prevent further timing pulses from

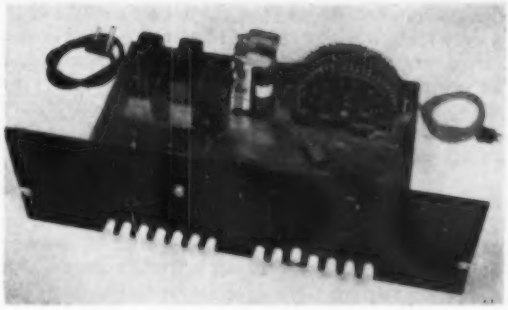


Fig. 2. The complete timing unit.

operating the uniselector. Contacts B/5 and B/6 are reserved for use with the automatic sample changer.

The apparatus will remain in this state until the scaler is reset. When this occurs, relay C is energized, C/1 cuts off the current holding relay B energized, and C/2 opens to prevent timing impulses from operating the uniselector, When the scaler is switched to 'count', relay C is de-energized, C/2 closes, and the next timing impulse operates the uniselector, thus starting a new timing cycle.

If a timing period of more than 48 minutes is selected, contact bank IV comes into operation at the 48th minute. By this means, relay D is energized and is held on via C/3 and D/2, while D/1 switches the 24 V supply from bank II to bank III to permit times of 49-98 minutes to be used. On resetting the scaler, C/3 opens, relay D is de-energized and D/1 switches the 24 V supply from bank III to bank II, ready for the next timing period.

Should it be desired to reset the scaler and start counting again before the end of the selected time, then

TABLE I

Performance of the Timing Unit

Time of counting (minutes)	*Counts observed*	*Deviation from expected counts*
90	269 996	—4
10	29 996	—4
5	14 997	—3
1	2 995	—5
1	2 995	—5
1	2 996	—4
1	2 999	—1
1	2 999	—1
1	2 996	—4
1	2 997	—3
1	2 997	—3
1	2 999	—1
1	2 997	—3

(The one minute counts were made consecutively)

this operation will also reset the uniselector (via C/1), it only being necessary to hold the scaler 'reset' switch closed long enough (about one second) for resetting to be complete. Also the time period selected may be changed while the timer is operating, though care should be taken not to select a new time shorter than that already elapsed.

Performance

The performance of the timing unit was checked by counting the 50 c/s test facility of the scaler for different times. Typical results are shown in Table I, from which it can be seen that the greatest deviation from the expected counts corresponds to a time difference of about 0·1 second, whatever the counting period. This small error is thus probably associated with the start or finish of the whole timing cycle rather than with operation of the timing contactor or uniselector when marking minutes. It must be pointed out that this test does not show the absolute accuracy of the unit, which is dependent on the frequency of the mains supply, because both the synchronous motor of the contactor and the nominal 50 c/s test circuit of the scaler will be affected equally by changes in mains frequency.

The general appearance of the unit, built on a chassis attached to a standard 19 in. rack panel, is shown in Fig. 2.

ACKNOWLEDGMENTS.—*The author would like to thank Mr. E. A. Jones for photographing the apparatus and Mr. E. C. Parham for drawing the circuit diagram.*

DETERMINATION OF PHASE SEQUENCE IN THREE-PHASE SYSTEMS

by Ing.Dr. M. P. Varshney, B.Sc., B.E. (Hons.), Ing.Dr. (Paris)

Asst. Professor of Electrical Engineering, Indian Institute of Technology, Kharagpur, India

PHASE-ROTATION relays and similar control-board instruments are usually based on the principle of induction wattmeters. However, a simple phase-rotation indicator employing an unbalanced star-connected circuit can be made with two similar incandescent lamps (serving as visual indicators) and an inductance (preferably iron-cored) or a condenser. The principle is fairly well known and Fig. 1 and 2 indicate the connection and vector diagrams (drawn from equivalent delta circuits) for the two cases respectively when the reactance in branch 03 equals the resistance of one of the lamps.

In practical form a condenser of capacity 1 to 2 μF. with ordinary 25 W. or 40 W. lamps is suitable for 220 V.-50 cycles circuits. The voltage impressed on one lamp is about 80 per cent and upon the other about 25 per cent of the line voltage. The phase connected to the bright lamp is leading with respect to that connected to the dim lamp, or in other words the phase connected to the dim lamp lags behind the phase connected to the bright lamp.

A modification of this circuit, making use of a neon-lamp and radio resistances and condenser, when suitably arranged results in an indicator of very small volume and so is very handy. The diagram of connections and the vector diagram are shown in Fig. 3.

For $R + R' \gg r$, if $r = 1/C\omega$, the triangle 102 is a right angled isosceles triangle, and the voltage across the neon-lamp will have a value

$$= \frac{R}{R + R'} \times \overline{03} \text{ when the sequence is 123,}$$

$$\text{and} = \frac{R}{R + R'} \times \overline{03'} \text{ when the sequence is 132.}$$

$$\text{But } \overline{03} = V\left(\frac{\sqrt{3}}{2} - \frac{1}{2}\right) = 0{\cdot}366V,$$

$$\text{and } \overline{03'} = V\left(\frac{\sqrt{3}}{2} + \frac{1}{2}\right) = 1{\cdot}366V, \text{ where V is the line voltage.}$$

If v is the voltage at which the neon-lamp glows, it will remain dark in the first case for

$$0{\cdot}366\ V \frac{R}{R + R'} < v$$

and will glow in the second case for

$$1{\cdot}366\ V \frac{R}{R + R'} > v.$$

This gives a fairly large margin for the choice of $(R/R + R')$ so that,

$$\frac{v}{V} \times \frac{1}{1{\cdot}366} < \frac{R}{R + R'} < \frac{v}{V} \times \frac{1}{0{\cdot}366}$$

It should be noted that the glowing of the neon-lamp alters the voltage at its terminals, but nevertheless it continues to glow.

An apparatus suitable for operation at 220 and 380 V. will result in glowing of the lamp for

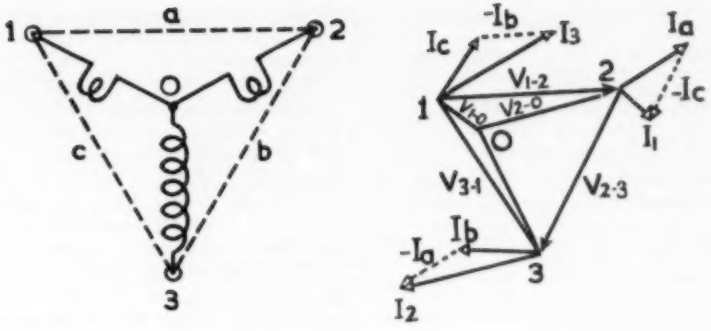


Fig. 1.

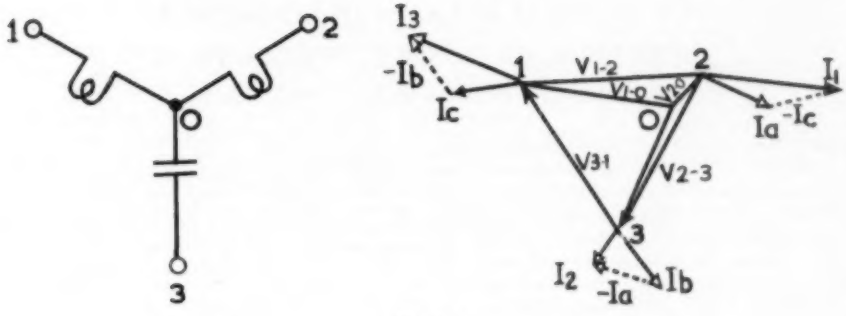


Fig. 2.

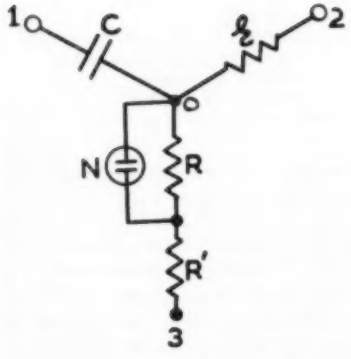
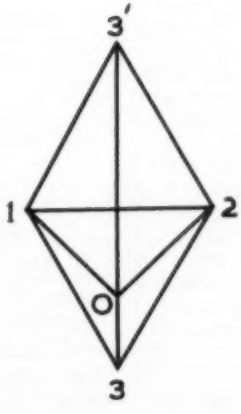


Fig. 3.



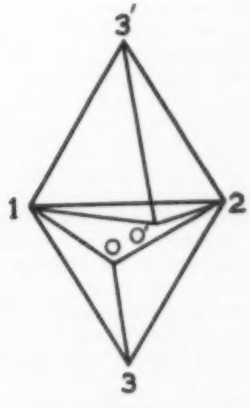


Fig. 4.

$$0{\cdot}366 \times 380 \times \frac{R}{R + R'} < v < 1{\cdot}366 \times 220 \times \frac{R}{R + R'}$$

$$\text{for } v = 120 \text{ V say, } 0{\cdot}396 < \frac{R}{R + R'} < 0{\cdot}864$$

or R/R′ should lie between 0·654 and 6·25.

In practice the following standard resistances and condenser were employed and worked satisfactorily:

R = 6·7 MΩ

R′ = 4·7 MΩ

C = 5,000 pF.

r = 670 kΩ (r = $1/C\omega$ gives a value of 636 kΩ)

When the lamp does not glow, the phase sequence is 1-2-3, while in the alternative case of the lamp glowing, the sequence is 1-3-2.

The whole equipment is very compact and can be accommodated in a cylinder of dia. 1·5 cm. and 5 cm. long, and can be used for 220 and 380 volts supply directly without any modification. It should be noted that in Fig. 3, if $R + R' \gg r$ or $r \neq 1/C\omega$, the triangle 102 will no longer be right angled isosceles. For $R + R' \gg r$, the point O will occupy two different positions 0 and 0′ depending on the positions 3 and 3′ for the vector triangle, i.e. for reverse phase sequences as shown in Fig. 4. But the apparatus still works satisfactorily because of the sufficient margin available.

A SIMPLE MANOMETER FOR PRESSURE MEASUREMENTS IN A SMALL CONFINED SPACE

by R. Galun, Ph. D., and S. Dickstein, Ph. D.

Israel Institute for Biological Research, Ness-Ziona, Israel

IN connection with the study of insect respiration at reduced pressures, it was necessary to measure the pressure in confined spaces such as closed desiccators. As the latter had to be moved and shaken frequently, external connections were undesirable. Most of the commercially available barometers are too large for this purpose and too expensive when many of them are required. Therefore, a small inexpensive manometer has been designed. A respiratory tambour was modified as follows:

The membrane was replaced by a piece of neoprene, about 1 mm. thick, and the pointer glued to its centre. A semicircular scale was attached, as shown in Fig. 1. The apparatus was connected by a rubber tube to a vacuum pump and evacuated to the required pressure, i.e. to the middle of the range required for the planned measurements. Thus the maximum sensitivity was obtained at the pressure attained when the apparatus was previously evacuated. The rubber tube was closed and the pump disconnected. The whole apparatus was placed in a desiccator which was connected to a vacuum pump and a mercury manometer. The pressure was reduced slowly and the numbers on the scale were calibrated against the mercury manometer.

Changes in sensitivity can be achieved by varying the thickness of the membrane, i.e. its elasticity. By increasing the sensitivity, the range of measurement is narrowed. The whole device can be prepared in any ordinary workshop or laboratory from a piece of metal tubing and an empty small food can.

ACKNOWLEDGMENT.—*We thank Mr. I. Wolf for the drawing.*

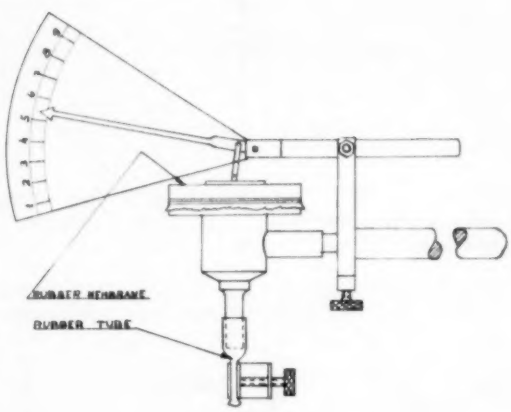


Fig. 1.

APPARATUS AND DEVICES

It is evident from letters received that the Apparatus and Devices Section of *Laboratory Practice* arouses considerable interest. We should like to point out that we are at all times pleased to receive from readers notes, however short or simple, for inclusion in this section.

News from the British Association of Chemists

Award to B.A.C. Member

Mr. A. Hilliard, Technical Adviser to the Société Carbon-Lorraine, has won the Second Research Award in the Waverley Gold Medal competition of the Royal Society of Arts, for his paper 'The Polybloc System of Construction for Anisotropic Materials'. The presentation took place in London on Monday, October 31, 1960 in the apartments of the Society.

The Scientific Advisory Board which judged the competition, comprised the following:

Chairman: Sir Alexander Fleck, F.R.S.
Secretary: Prof. R. S. Hutton, D.Sc.
Members: Sir Edward Appleton, C.B.E., F.R.S.
Sir Linder Brown, C.B.E., F.R.C.P., F.R.S.
Sir Charles Darwin, K.B.E., M.C., F.R.S.
Rt. Hon. Earl of Halsbury, F.R.I.C., F.Inst.P., M.I.Prod.E.
Sir Edward Salisbury, C.B.E., F.R.S.
Sir Edward Smith, M.A., F.R.S.

Appointments Service

The Association's weekly Appointments Circular continues to be of great assistance to members seeking a change of post and also to employers who have chemical vacancies of all kinds. During the year to September 30, 1960 the number of vacancy announcements in the circular was approximately 6,000, and this service has proved of the utmost value to B.A.C. members who, through this service, have each had put before them every week the details of a very wide variety of chemical vacancies.

Obituary

The decease of the following members is recorded with regret:

L. Hebbs. Elected Member 1930.
W. Sutherland. Elected Member 1920.

Federation Internationale des Cadres de la Chimie et des Industries Annexes

A meeting of the Comité Directeur of F.I.C.C.I.A. was held on October 15 and 16 at Monaco in conjunction with the 4th International Congress of the Confédération Internationale des Cadres. F.I.C.C.I.A. being a member of the C.I.C., their delegates also attended the Congress. Mr. H. L. Howard, Hon. Registrar of the B.A.C., attended both meetings as the representative of the B.A.C.

On this occasion the Fédération Monégasque des Cadres was formally admitted to membership of the C.I.C. The delegates were entertained officially by the Monaco Municipality and also by the Mayor of Nice. A number of matters of interest to professional men generally were dealt with at the meetings and it is hoped to be able to give some details of these later. It was reported that Signor Giuseppe Togni, President of the C.I.C., had visited the United States for the purpose of establishing contacts with American organizations of professional men. Signor Togni met in New York, representatives of the American Management Association and during the course of the meetings it was recognized that the respective organizations had almost identical aims. Signor Togni also visited Washington, where he met the Ministers of Commerce and the Treasury, as well as other high officials. He was also a guest at a luncheon given at the White House. After this Signor Togni went to San Francisco, Chicago and Boston. The result of this journey has been the creation of new bonds of friendship and co-operation between those organizations of professional men which hold great responsibility in the field of economic and social development, and invitations have been extended to the American 'Cadres' to attend the next International Congress of the C.I.C.

Formation of New Branch

In view of the number of members resident in the area it was decided to form an 'East London and Essex Branch' of the London Section. This new Branch is now actively in operation. The Branch has already held two meetings which have been very well attended and a very popular item on the agenda is 'Any Questions'. Any member present can ask any question that he wishes and the Committee will do its best to answer on the spot, or obtain the necessary information later.

A programme for 1960-61 has been arranged which includes visits to the 'Daily Telegraph' headquarters, the Guinness Brewery, and a Scientific Film Show. All those who have attended the meetings have found them not only instructive, but very enjoyable from the social aspect. The meetings are usually held in Barking and anyone who would like further information should communicate with the Hon. Secretary, Mr. Gilbert Robertson, 3 Rosslyn Road, Barking, Essex.

Salary Scales

The B.A.C.'s Salary Scale Committee has issued a Revised Scale of Minimum Salaries for Chemists and Chemical Assistants. There are a number of increases in the remuneration provided in the previous Scales in the case of certain grades.

The number of employers who have asked to be put on the mailing list for receiving our Salary Scales is now over 500. In addition employers continue to seek the advice of the B.A.C. in connection with the remuneration of their staff, working conditions, etc.

Unemployment Benefit Fund

During the year ended September 30, 1960, the Fund paid a total of £439 to members who were unemployed for varying periods of time during that year. The majority of the beneficiaries were members over the age of 45 whose appointments had been terminated owing to re-organizations, etc.

During the year under review the Fund also made payments totalling £775 under Rule 22 of the Fund. These payments represented refunds of part of the individuals' contribution to the Unemployment Benefit Fund during their membership, which became due to them on reaching the age of 65, or prior compulsory retirement, and also to the estates of deceased members. The present rate of refund is 33⅓ per cent of the contributions, subject to adjustment in respect of unemployment benefit which may have been drawn in the past. In some cases the refund amounted to over £50 and the recipients found this a most welcome 'windfall' on their retirement. Notwithstanding these disbursements, the Unemployment Benefit Fund showed a surplus of over £1,000 on the year's working, and the Reserve is equivalent to the amount required to pay every contributor full unemployment benefit for six months.

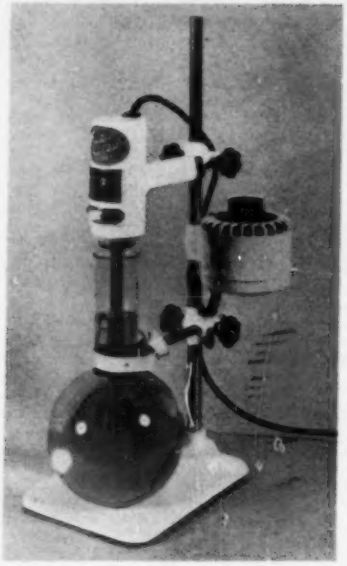
News from the London Section

This year the members of the London Section again received an invitation from Shell-Mex and B.P. Ltd. to attend a Scientific Film Show given in their excellent cinema theatre at Shell-Mex House, Strand, London. This was a most successful function. Ninety members attended and our hosts most kindly provided refreshments for them.

Among the films shown was 'The Development of Speed Photography', a splendid technical production, showing among other things, the fracture of glass, penetration by bullets, and air disturbance by aircraft, including the Schlieren effect. In addition there was a film showing the procedure followed when it became necessary to divert tankers already at sea and their replacement by others, illustrated by an actual example. Another film dealt with the development of the Shell Company. After the show Mr. Robertson, the Chairman of the London Section, expressed the members' great appreciation of the entertainment and hospitality so kindly provided.

All correspondence and enquiries concerning this Association should be addressed to G. R. Langdale, Esq., The British Association of Chemists, Nomination Dept., 14 Hurley Street, London, W.1. Tel.: Museum 7021.

LABORATORY EQUIPMENT & APPLIANCES



Kinematic High Frequency Mixers

The latest range of Swiss-made Polytron kinematic high frequency mixers embodies several design improvements based on a decade of industrial user experience in Europe and America. The Polytron processing system represents a marked advance in homogenization, emulsifying and dispersion technique. In addition to the normal forces associated with turbulence which influence the mixing process in conventional high speed propeller-type mixers, energy is released at a much greater intensity by cavitation at ultrasonic frequencies. The remarkable increase in efficiency due to cavitation, both in reduction of process time and in the quality of the product, is well known. However, the electronic generation of high intensity ultrasonic vibrations above the cavitation threshold is expensive and inflexible in application, particularly for the processing of larger volumes of material. It is this fact which has retarded the general spread of high frequency mixing techniques in industry.

The Polytron overcomes these disadvantages by using a system which is little more complex than the conventional high speed rotary mixer. Sonic or ultrasonic vibrations are generated by means of a specially designed toothed rotor rotating within a coaxial toothed stator. High energy impulses are generated as the rotor teeth rapidly pass those of the stator; the number of impulses per revolution is determined by the product of the rotor and stator teeth. For example, the Polytron Model 35 ST with three teeth on the rotor and 12 teeth on the stator generates 576,000 impulses/min. at 16,000 r.p.m. which is equivalent to 9,600 cycles/sec. Other models, by means of concentric rings of teeth, generate frequencies up to the order of megacycles/sec.

No premixing or stirring is necessary. In many applications the high intensity of energy reduces the process time from several hours to a few minutes.

A wide range of models is available, from a micro apparatus to production installations.

Consistencies may vary from coarse particle or fibre suspensions down to low viscosity Newtonian fluids. In addition to the portable models, a range of fixed bench or floor mounted installations is available with integral mixing chambers. In all models the frequency is adjustable to the optimum value which gives maximum mixing efficiency for a given material.

(Available from: Scientific Furnishings Ltd., Poynton, Cheshire.)

Direct Reading Oscillograph

Following the lifting of import restrictions on oscillographs from the United States, a British company have arranged with their U.S. associates to market a 14-channel direct reading oscillograph known as the Visicorder at a basic selling price of £750.

Initial delivery time is given as three months, but instruments will shortly be available from stock. Standard accessories and spares will also be stocked for immediate delivery.

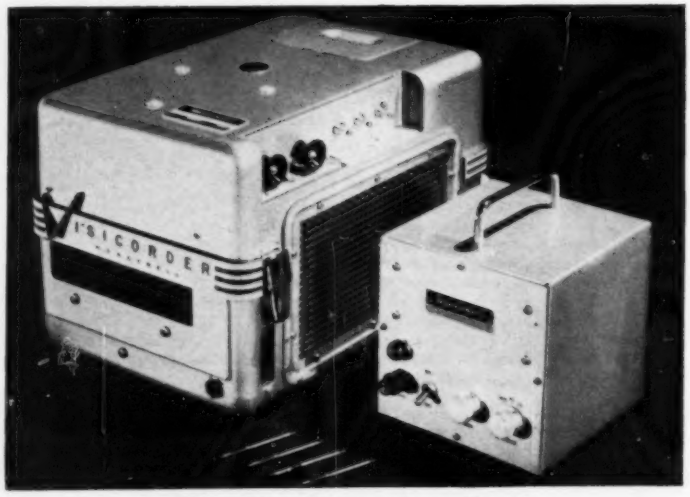
Known fields of application for this instrument include weather and earthquake studies, space vehicle tracking, air flow and wind tunnel research in the aircraft industry, high speed gas-liquid chromatography, medical investigations and industrial research in the nuclear, oil, chemical, communication, steel, motor, electrical and other sectors.

The Visicorder resembles a conventional oscillograph with its light source, mirror galvanometers, optical system and paper transport system. But no chemical means are used to obtain a permanent record. There is no ink, electrostatic charge, electric arc, chemical vapour or heat.

Using six-inch wide paper, frequencies up to 5,000 cycles/sec. can be recorded on 12 channels, with two reference or timing traces. Intensity control, grid line system and trace identification are provided.

The instrument lends itself to remote control as it contains a self-starting recording lamp. There is a built-in power pack.

(Marketed by: Honeywell Controls Ltd., Greenford, Middlesex.)



Fourteen-channel direct reading oscillograph.

Ultrasonic Cleaning

The new Type 1160/T52 1½ gallon (B.I.) ultrasonic cleaning tank has a 40 kc/s piezo-electric transducer mounted within the tank base, covering the full floor area. The unit is designed for use with Type 1150 500/125 W. generator and is cleaner in design and considerably cheaper than the previous version. It is built of welded stainless steel, with internal tank dimensions of 8 in. × 6½ in. × 10 in. deep. The overall depth is 13½ in. and it has a 1 in. flange at the upper edge, enabling the unit to be mounted in a bench aperture.

The unit is suitable for small-part production line cleaning, surgical instrument and hypodermic needle and syringe cleaning, and for laboratory and experimental work on cleaning, plating, solvent acceleration and tissue disintegration. It is recognized that in most cleaning applications ultrasonic action gives faster and more complete removal of soils than conventional techniques, producing excellent results even in crevices and cavities inaccessible to other techniques.

(Manufacturers: Dawe Instruments Ltd., 99-101 Uxbridge Road, Ealing, London, W.5.)

A New Portable Microbalance with Six Ranges

The recently introduced Cahn Electrobalance represents a radical advance in micro-weighing instrumentation.

This ruggedly constructed balance, operated by long-life batteries, is truly portable, weighing only 12 lb., and requires no special bench—any table, desk or cabinet provides a satisfactory base. It is unaffected by vibration, temperature and draughts and requires no levelling. It is extremely fast in operation and calls for no special skill. The weighing chamber, 6 in. × 6 in. × 3 in., is removable and may be operated by remote control through four electrical connections. Disposable sample pans, simply cut from foil, may be used in place of the standard pans, if required.

The Electrobalance has six readily selected ranges from 0-1 mg. up to 0-100 mg. In the 0-1 mg. range both reproducibility and accuracy are within 1 microgram. In the 0-100 mg. range, reproducibility is within 25 micrograms and accuracy within 100 micrograms. Comparable figures apply to the intervening ranges.

A special feature is the ultra-rapid calibrating facilities which enable it to be kept at the highest pitch of accuracy.

In many laboratories the portability of the Electrobalance and the fact that it operates over six different ranges enable it to replace several other balances of more conventional design.

(Available from: Shandon Scientific Co., Ltd., 6 Cromwell Place, London, S.W.7.)

The Cahn Electrobalance.

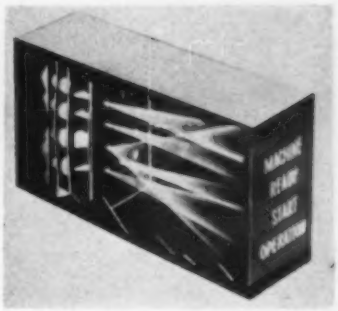
Digital Display Unit

A new improved Series 80,000 digital display unit will now display words backlighted with colour.

It is possible to display words such as Machine, Ready, Start, Operation, etc. or any other combination of words desired by the user. In addition, red, orange, yellow, green or blue colours may be displayed on the screen either by themselves or as background for the word messages, the desired colour being selected by the user.

It is designed for visual communication and operations control with fully-automatic, semi-automatic, or manually operated equipment. It saves time, saves labour, and increases the efficiency of personnel and operations.

The unit operates on a rear-projection principle, and contains a master condensing lens with 12 individual positions or lenses. On each lens is printed the desired word, message, or colour. When one of the 12 lamps at the rear of the unit is lighted, the lamp projects the corresponding word or colour on to the viewing screen at the front of the unit.



Series 80,000 digital display unit.

The word message may be used by itself, or a coloured background light may be projected simultaneously to indicate the condition or situation.

(Manufacturers: Counting Instruments Ltd., 5 Elstree Way, Boreham Wood, Herts.)

RAACO Storage Unit

The Raaco industrial range of storage cabinets has been specifically designed for laboratory or shop-counter use for the storage of small fragile containers, bottles and capsules. The drawers, made in transparent toughened plastic, with label holder, back stop and adjustable to provide smaller sections by sub-dividers, are contained in a sheet metal cabinet which can be stacked or fastened to a wall. In this way large compact storage installations can be built up apart from its versatility in use as individual bench units.

(Manufacturers: James H. Randall & Son Ltd., Paddington Green Works, London, W.2.)

The RAACO storage unit.

NEWS

General

Physical Society Exhibition

The Annual Exhibition of the Institute of Physics and the Physical Society will be held at the Royal Horticultural Society's Old and New Halls, Westminster, S.W.1. from January 16 to 20, 1961.

During the Exhibition, the following discourses and demonstration lectures will be given:

Jan. 17. Hydrodynamic Research by Mr. F. S. Burt (Admiralty Research Laboratory).

Jan. 18. The Physics of the Ocean, by Dr. G. E. R. Deacon (National Institute of Oceanography).

Jan. 19. Some Physical Problems in Travelling at Supersonic Speed by Dr. F. P. Bowden (Laboratory for the Physics and Chemistry of Solids, Cambridge).

It is hoped to include a comprehensive preview of this exhibition in the January issue of *Laboratory Practice*.

Manufacturers' News

Repair Services

Industrial Instrument Services Co., are the British Agents for the Sales and Technical Service of the Wheelco Instrument Division of the Barber-Colman Co., Rockford, Illinois, U.S.A.

Their services include a repair and reconditioning service for all existing Wheelco pyrometer instruments, with a complete range of thermocouples to suit any type of instrument and application.

They have recently moved to larger premises, the new address being Elkington Street, Aston, Birmingham, 6. *Tel.*: ASTon Cross 2771.

An Introduction to Ion Exchange

Ten years ago, knowledge of ion exchange was confined to a comparatively small number of experts, and its commercial use was limited almost entirely to water softening and water demineralizing.

Since then, interest has grown rapidly, and the chemical literature now describes an increasing use of ion exchange in analysis and research, and in large scale chemical production. The subject is frequently included in degree courses, and numerous excellent text-books have been published. The Royal Institute of Chemistry has produced an instructional film strip, and learned societies have included lectures on ion exchange in their programmes. In many of these activities, The Permutit Company Limited has co-operated in spreading knowledge of the subject.

Despite these efforts to keep pace with the widening scope of ion exchange, cine film—the ideal instructional medium—has so far been neglected. Permutit consequently decided to remedy this omission, and has now produced an instructional film in sound and colour that will form an introduction to the subject, both for students and for potential industrial users.

The film opens with a rapid survey of the uses of ion exchange in industry and research. Then, with the use of molecular models, the structure of ion exchange resins is examined. Two of the most frequently used types—the strong acid cation exchanger and the strong base anion exchanger—are shown: the models illustrate the incorporation of the active groups into the polystyrene network and the inter-relation of the fixed and mobile ions with the resin skeleton.

A description is then given of the three major principles on which all ion exchange applications are based—those of separation, substitution and removal of ions. Three typical laboratory experiments are shown, advantage being taken of the ability of the camera to speed up movement so that an experiment occupying many hours can be observed in a few seconds. Separation is illustrated by the use of two coloured organic ions, one of which is held by the resin while the other passes through. The conversion of potassium permanganate solution to potassium dichromate is used to illustrate the process of substitution, while removal is shown by demineralizing a copper dichromate solution.

This last process is then considered in greater detail in order to explain the basis of the ion exchange technique. Animated diagrams are used alternatively with column experiments to show what is happening both in solution and inside the resin beads.

The principles of two bed and mixed bed demineralizing are illustrated, both in the laboratory and on industrial scale, and examples are given of the uses of demineralized water in industry.

The film which runs for 27 minutes, is produced on 16 mm. colour stock, and has an optical sound track.

Publications

Petroleum Equipment and Services

The Council of British Manufacturers of Petroleum Equipment announces the publication of the 1960 edition of the 'Classified List of Equipment and Services', revised and enlarged to bring up to date the information in the biennial catalogue 'British Petroleum Equipment' 1959/60 edition. This separate edition lists an additional 78 members. There has also been considerable extension of headings and subheadings to cover the widening sphere of members' activities and to facilitate the rapid location of equipment items and the manufacturers concerned.

Copies are available from the Council Offices, post free 10s. each.

Nuclear Engineering Abstracts

A new abstracting journal, with the accent on engineering, has been published by Silver End Documentary Publications Ltd. of 9-11 Tottenham Street, London, W.1. The journal will be of interest to the engineer engaged in nuclear work, the scientist employing nuclear instruments, the manufacturer and operator of nuclear plant and the industrialist planning to enter the field and wishing to familiarize himself with conditions.

Several hundred journals are to be constantly reviewed and the informations presented will be selected in co-operation with renowned experts.

Periodicals in the Chemical Society Library

A list has been compiled by the Chemical Society showing the complete periodical holdings of its library. This is available from the Society at 5s. and should prove a valuable reference guide for those who use the library.

Reagent for Iron

Monograph 41 dealing with 4:7-diphenyl-1:10-phenanthroline (Bathophenanthroline) reagent for iron, by E. J. Newman, B.Sc., A.R.I.C., and G. Peters, is the latest in the series of monographs on organic chemical reagents published by Hopkin & Williams Ltd., Chadwell Heath, Essex.

Personal Notes

Mr. R. G. Weaver

In keeping with the continued expansion policy of D. A. Gunn (Engineering) Ltd., Mr. R. G. Weaver has been appointed sales manager to handle DAG submersible pumps and vacuum ovens.

Dr. John D. Kendall

Dr. John D. Kendall has been appointed Director of European Research Laboratories by the Minnesota Mining & Manufacturing Co., Ltd.

Dr. Kendall was for many years responsible for the direction of organic chemical research at Ilford Ltd. In his newly created post, he will be responsible for setting up a European research operation. The first assignment for the new laboratory organization will be the development of new graphic products, although the scope of the organization's work will not be limited to this area.

Electrothermal®
RED-ROD

The Electrothermal "Red-Rod" provides a compact, convenient, and powerful source of heat which lends itself ideally to the heating of liquids.

The advantages of the "Red-Rod" over other types of immersion heaters are due largely to a special construction employing quartz :-

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Trace Reading Equipment for Italy

Southern Instruments Export Department have, after negotiations lasting over four years conducted by their Italian Agents, Conway Dolman, received an order from the Marine Branch of the Italian Government Aeronautical Defence.

The equipment, TRE12, consists of a trace reader and a 4 ft. rack containing power supplies, digitizer, scaling amplifier, range setting facilities, and output units for feeding the typewriter, tape perforator, etc. (*See* illustration.)

In this instance it will supply digital as well as coded information for a Ferranti Mark I computer and will, in addition, operate a Benson Lehner plotter. The TRE12 equipment is already in use in the aircraft industry where it is used for analysing flight test records.

Catalogues, Brochures and Leaflets Received from Manufacturers

Protection in Packaging.—The Expanded Rubber Group of Companies of Mitcham Road, Croydon, Surrey, have published a new booklet dealing with the protection and cushioning of goods in transit. Part of the booklet gives a treatise on shock damage and its elimination, and the theory of cushion design. The rest deals with the cushioning and protection materials made by the Group.

Non-destructive Testing.—An information booklet has been produced by Solus-Schall Ltd., of County Building, Honeypot Lane, Stanmore, Middlesex, which reviews the site methods of non-destructive testing provided by the company, including visual welding inspection, X-radiography, gamma radiography, penetrants, ultrasonic flaw detection and magnetic particle inspection.

Marconi Instrumentation.—The September 1960 issue of *Marconi Instrumentation* published by Marconi Instruments Ltd., St. Albans, Herts., contains articles on a co-axial slotted line (TF 1264), ¼ per cent universal bridge (TF 1313), D.C. choke adaptor (TM 6113), the Marconi wide-band millivoltmeter (Type TF 1371), heterodyne frequency meters (TF 1067 and 1067/1), transformer design and test using the Marconi universal bridge TF 868B and an application note dealing with delayed triggering operation using two standard TF 1330 oscilloscopes.

N. & Z. Publications.—Negretti & Zambra, 122 Regent Street, London, W.1, have recently issued two new publications. The first of these (catalogue T44/G) is a German version of their mercury-in-steel recording thermometer pamphlet and the other is a new Indian version of their general catalogue which will be circulated throughout India and Ceylon by our Indian agents, Bell's Asbestos & Engineering (India) Private Ltd.

MEETINGS FOR THE MONTH

Mid-December to Mid-January

We give below a selection of meetings of interest to laboratory workers. Details are as full as possible at the time of going to press, but readers requiring further information or confirmation of arrangements should contact the organizers.

December 8

The Society of Instrument Technology (Liverpool Section). At M.A.N.W.E.B. Industrial Development Centre, Liverpool. 7 p.m. 'Statistics,' by J. R. Judd.

The Society of Instrument Technology (Tees-side Section). At the Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough. 7.30 p.m. 'Chromatography,' by T. B. Kent, B.Sc., A.Inst.P. 'Practical Aspects of Plant Measurements,' by M. S. Beck, B.Sc.

The Society for Analytical Chemistry (Biological Methods Group). At 'The Feathers,' Tudor Street, London, E.C.4. 6.30 p.m. Discussion meeting on 'Problems in the Control of Neomycin Quality,' to be opened by J. W. Lightbrown, M.Sc., Dip.Bact.

December 9

Royal Institution of Great Britain. At 21 Albermarle Street, London, W.1. 9 p.m. 'Rocket Astronomy,' by R. L. F. Boyd, Ph.D.

December 12

The Society of Instrument Technology (Manchester Section). At the College of Science and Technology, Sackville Street, Manchester. 6.45 p.m. 'History of Pneumatic Control,' by G. E. Twist, B.Sc.

December 13

The Society for Analytical Chemistry (Midlands Section). At the Regent House, Birmingham. 6.30 p.m. 'The Analysis of Waters used in Industry,' by K. B. Coates.

December 14

The Society of Instrument Technology (Bristol Section). At Transport House, Victoria Street, Bristol, 1. 7.30. Joint meeting with invited members of the T. & G.W.U. 'Automation: Who Benefits?' Discussion by a team under the chairmanship of D. M. G. Sneddon.

The Institution of Mechanical Engineers. At 1 Birdcage Walk, Westminster, London, S.W.1. James Clayton Lecture. 'Machine Tool Research, Design and Utilization,' by Dr. D. F. Galloway.

December 15

The Society of Instrument Technology (Chester Section). At Blossoms Hotel, Chester. 7 p.m. Joint meeting with North Wales Metallurgical Society. 'Instrumentation in Steelmaking,' by N. P. Bacon, B.Eng., Ph.D., A.M.Inst.F.

The Society for Analytical Chemistry (Midlands Section). At the Technical College, Nottingham. 7 p.m. 'The Development of the Analytical Balance,' by K. M. Ogden.

December 17

The Society of Instrument Technology (East Midland Section). 10 a.m. Visit to Hosiery and Allied Trades Research Association, Gregory Boulevard, Nottingham.

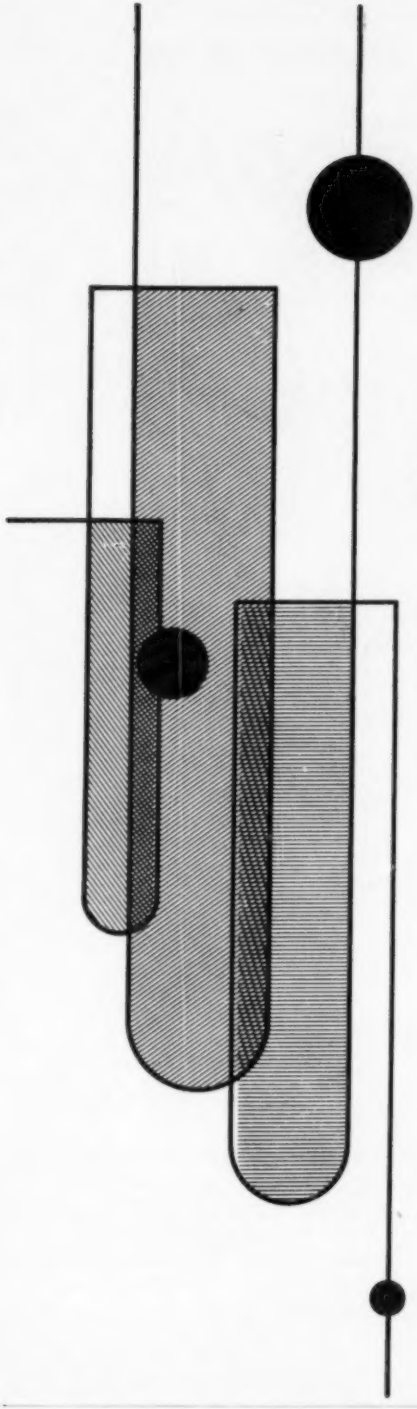
1961

January 4

The Society of Instrument Technology (South Yorkshire Section). At the University, St. George's Square, Sheffield, 1. 7 p.m. 'Instruments and Cherry Blossom—Some Impressions of a Technical Visit to Japan,' by W. C. Heselwood, B.Sc., A.Inst.Met., F.I.M.

January 6

The Society of Instrument Technology (Fawley Section). At the Administration Building, Esso Refinery, Fawley. 5.30 p.m. 'Electronics and Instrumentation in the Glass Industry,' by J. R. Beattie.



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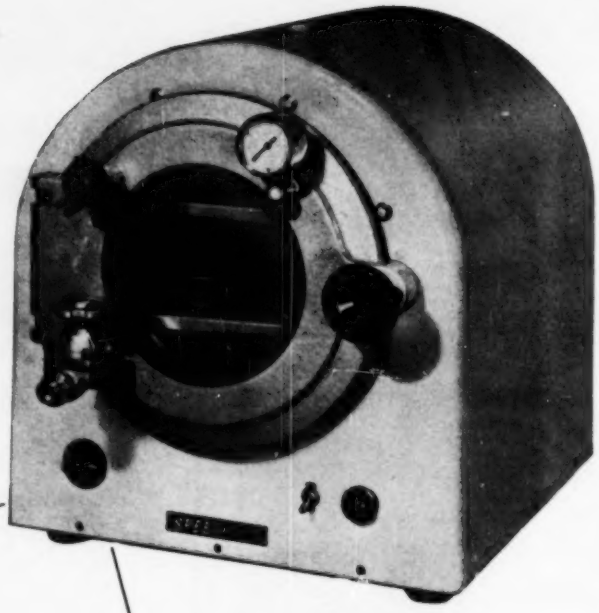

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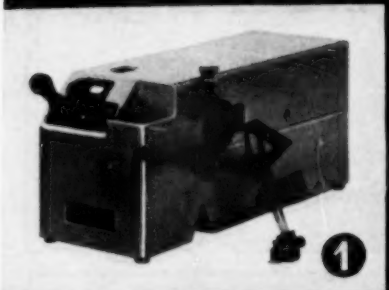

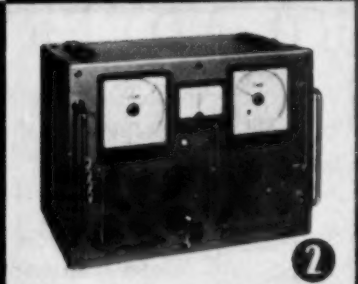

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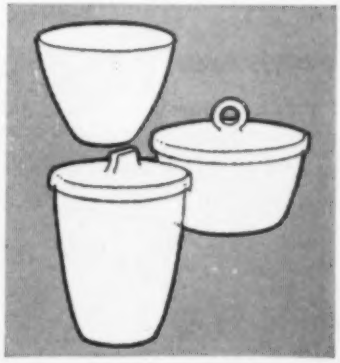

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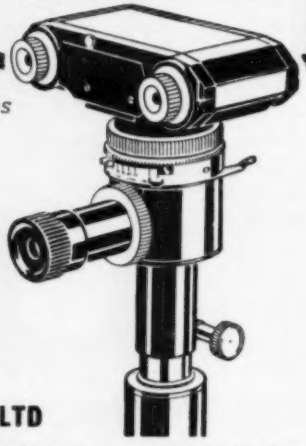

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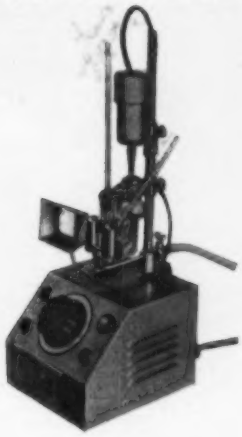

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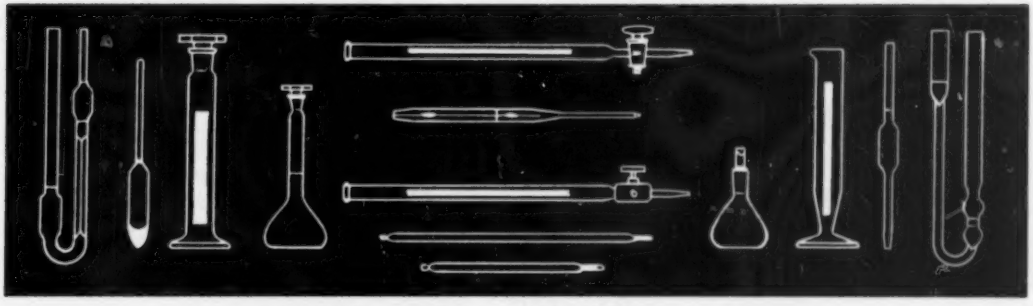

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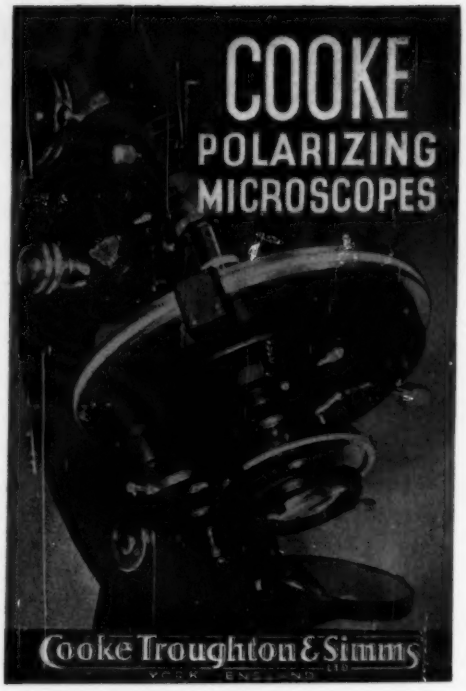

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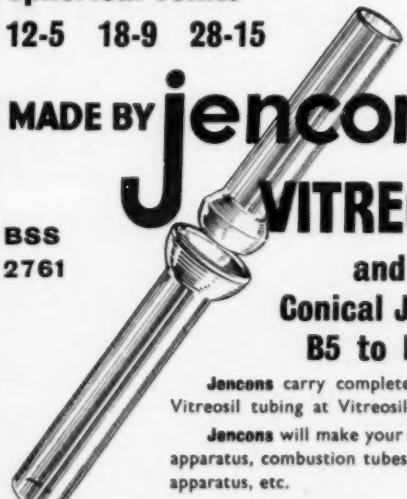

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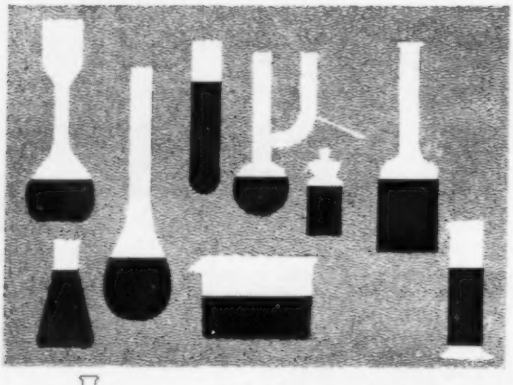

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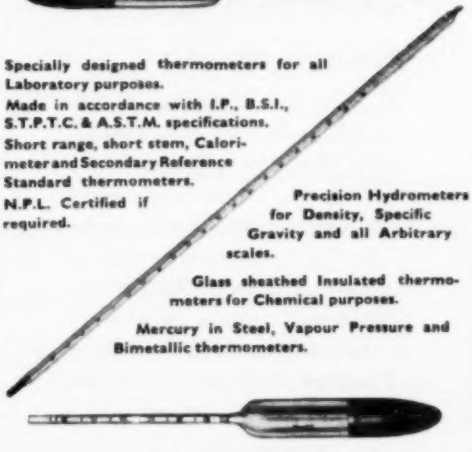

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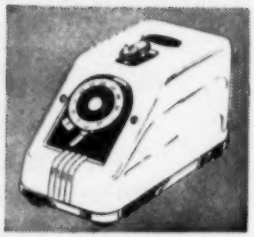

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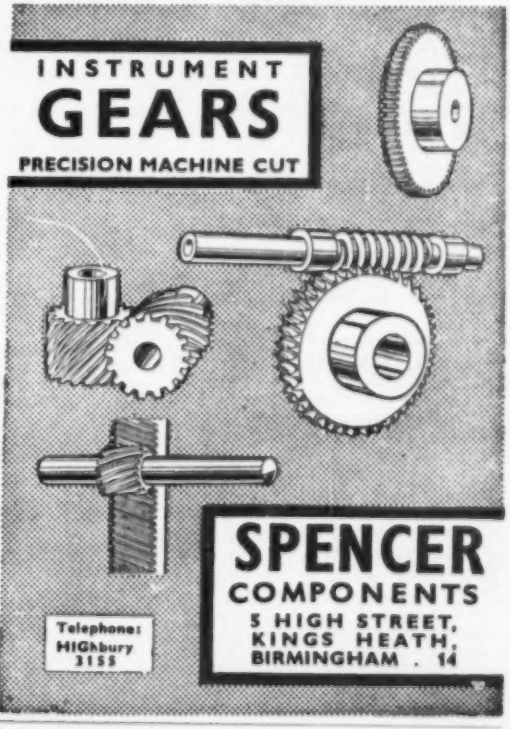

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